ARCHITECTURAL CONSERVATION TECHNOLOGY

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICE
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA

Canadian Heritage Patrimoine canadien
Parks Canada Parcs Canada

Canada Communication Group Publishing
Groupe Communication Canada Édition

ARCHITECTURAL CONSERVATION TECHNOLOGY

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICE
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA

Available in Canada through your local bookseller or by mail from Canada Communication Group - Publishing, Ottawa, Canada, K1A 0S9.

Published under the authority
of the Minister of the Department of Canadian Heritage,
Ottawa, 1994

CANADIAN CATALOGUING IN PUBLICATION DATA

Main entry under title:

ARCHITECTURAL CONSERVATION TECHNOLOGY

Issued also in French under title: Technologie de la conservation architecturale.
Complete work consists of 7 volumes.
Contents: Vol. I Project Management – Vol. II Heritage Recording – Vol. III Historic Site Analysis – Vol. IV Historic Site Design and Development – Vol. V Conservation Maintenance – Vol. VI Conservation of Materials – Vol. VII Period Construction Technology
ISBN 0–660–14657–6 (set); 0–660–14664–9 (Vol. VII);
DSS cat. no. W62–16/1993E (set);
W62–16/7–1993E – 7–1993E

1. Architecture – Canada – Conservation and restoration – Handbooks, manuals, etc.
2. Historic buildings – Canada – Conservation and restoration – Handbooks, manuals, etc.
3. Historic sites – Canada – Conservation and restoration – Handbooks, manuals, etc.
4. Cultural Property, Protection of – Canada.
   I. Canada. Public Works Canada. Architectural and Engineering Services.
   II. Heritage Conservation Program (Canada).

NA109.C32A72 1993 363.6'9'0971 C92–099751–1

NOTE: Since this manual was in production when federal goverment departments were restructured in 1993, it was impossible to update all in-text government references. The Canadian Parks Services (CPS) of Environment Canada is now Parks Canada of the Department of Canadian Heritage, and Public Works is now part of the Department of Government Services.

Included within the seven volumes of the ACT manual is both basic and specialized information on architecture, engineering and landscape works.

References at all levels within these disciplines, useful both in practice and in training, are intended to:

- introduce and familiarize the user with conservation concerns;
- serve as an "aide-mémoire" at both the design and managerial levels; and
- provide guidance to professional consultants responsible for recording and analysing historic structures, and applying recommended conservation methods to their protection and preservation.

All procedures outlined in these publications should be read in conjunction with the reference material, manufacturer's literature and the relevant Canadian Parks Service – National Historic Sites Management Directives.

In all matters where detailed specifications are required, such as building codes, fire regulations and the use of chemicals, the prevailing and local references and regulations must be consulted and applied.

Please note that the ACT manual has been prepared within the context of Parks Canada Policy (1979). The newly proposed Canadian Parks Service Policy (1990) establishes additional and broader directions that, however, do not alter the orientation of the technical material covered. The ACT manual reflects the well established principles of conservation as defined by national and international charters and conventions – see Vol. I Appendix.

Within the proposed policy, the Cultural Resource Management (CRM) section (see Vol. I, Appendix 5.17) establishes the overall framework for the conservation and presentation of the cultural assets administered by CPS, on all CPS properties, including those in National Historic Sites, Historic Canals, National Parks, National Marine Parks, and other CPS properties. In the event of a conflict between the direction provided by the ACT manual and that provided by CRM Policy, the latter applies.

Although great care has been taken to trace the ownership of copyrighted material used in the text (including illustrations), the demise or apparent disappearance of some publishing firms has made tracing nearly impossible. Therefore, the authors and publisher welcome any information enabling them to rectify references and credits in subsequent editions.

STANDING ORDERS

[] Standing Orders are accepted for periods of up to three years. At the end of the period requested (see below), a notice will be sent asking you to confirm that you wish continued provision of this service.

[] Invoices will be sent on quarterly basis.

[] The Canada Communication Group - Publishing must be informed in writing of a change of address and/or a change in quantities.

[] Any outstanding balances not paid within 30 days of the date of the invoice could jeopardize the continued provision of this service.

The Standing Order form below should be completed and returned to:
Canada Communication Group - Publishing
Ottawa, Canada K1A 0S9

STANDING ORDER FORM

Catalogue number	Title	Number of Copies	Period Requested
W62-16/1E	**Project Management** (Vol. 1)		[] 1 year [] 2 years [] 3 years
W62-16/2E	**Heritage Recording** (Vol. 2)		[] 1 year [] 2 years [] 3 years
W62-16/3E	**Historic Site Analysis** (Vol. 3)		[] 1 year [] 2 years [] 3 years
W62-16/4E	**Historic Site Design and Development** (Vol. 4)		[] 1 year [] 2 years [] 3 years
W62-16/5E	**Conservation Maintenance** (Vol. 5)		[] 1 year [] 2 years [] 3 years
W62-16/6E	**Conservation of Materials** (Vol. 6)		[] 1 year [] 2 years [] 3 years
W62-16/7E	**Period Construction Technology** (Vol. 7)		[] 1 year [] 2 years [] 3 years

A service fee of $3.00 per volume is charged per address to which standing orders are shipped (irrespective of the number of copies shipped to an address, and irrespective of the period requested, i.e. from 1 to 3 years). If applicable, add 7% GST.

Purchase orders are accepted from governments, registered companies and educational institutions. (Federal Government - Please use purchase orders only)

♦ Purchase Order No.: |__|__|__|__|__|__|__|__|__|__|__|__|

Others are required to prepay the $3.00 service fee.
(Orders from outside Canada - payable in US dollars).

[ ] Cheque/Money Order (payable to the Receiver General for Canada) enclosed.

[ ] Visa/MasterCard |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

Credit Card Expiry Date: ____/____ Date: ____/____/____

Signature: ________________________________

SHIP TO:

NAME ________________________________

FIRM/ORGANIZATION ________________________________

ADDRESS ________________________________ CITY ________________

PROVINCE ________________________________ POSTAL CODE |__|__|__| |__|__|__|

CONTENTS

Architectural Conservation Technology (ISBN 0-660-14657-6; DSS Cat. no. W62-16/1993E) is a manual of seven volumes. Each volume may be bought separately. Here are the contents and numbers for each one.

VOLUME I: PROJECT MANAGEMENT

ISBN: 0-660-14658-4
DSS: W62-16/1-1993E

VOLUME II: HERITAGE RECORDING

ISBN: 0-660-14659/2
DSS: W62-16/2-1993E

VOLUME III: HISTORIC SITE ANALYSIS

ISBN: 0-660-14660-6
DSS: W62-16/3-1993E

VOLUME IV: HISTORIC SITE DESIGN AND DEVELOPMENT

ISBN: 0-660-14661-4
DSS: W62-16/4-1993E

CONTENTS

VOLUME V: CONSERVATION MAINTENANCE

ISBN: 0-660-14662-2
DSS: W62-16/5-1993E

VOLUME VI: CONSERVATION OF MATERIALS

ISBN: 0-660-14663-0
DSS: W62-16/6-1993E

CONTENTS

VOLUME VII: PERIOD CONSTRUCTION TECHNOLOGY

ISBN: 0-660-14664-9
DSS: W62-16/7-1993E

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

1
CONSTRUCTION ORGANIZATIONAL DEVELOPMENT IN CANADA

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

This article discusses the historical developments in the organization of the building trades and professions in Canada in order to provide a framework for understanding period construction. It considers the nature and the organization of the various groups who have engaged in designing and constructing buildings during the post-contact period. In addition, it describes building regulation and the diffusion of skills, indicating how changes in these factors have affected the built form. The text provides only a summary of this complex and, as yet, inadequately studied topic. Suggestions for further reading are provided in the bibliography.

The text makes a distinction between the building trades (e.g. carpenters and contractors) and design professionals (e.g. architects and engineers), even though this separation has been clear in Canada only in relatively recent history. In earlier periods many carpenters and contractors were also designers. Nevertheless, there have always been professional designers who have set themselves apart from the builders and who have been influential in the dissemination of new ideas through their teachings, publications and designs. The separation of the designers and the builders goes back to the Middle Ages, to the distinction made between the liberal and the mechanical arts. The former were primarily intellectual. In many respects the development of the architectural profession has involved a justification of the supposed superiority of the former and an attempt to establish a distance from the latter. Aspects of this subject are discussed in 2 and 3 below.

2.0 THE BUILDING TRADES

2.1 ARTISANS AND CRAFTSPERSONS

In the Middle Ages and into the Renaissance, building was the charge of groups of artisans (or artificers), each of which practised a separate trade. There were masons, stonecutters, carpenters, joiners, sawyers, roofers, blacksmiths, glazers, painters and others. Many adopted their trade as a hereditary responsibility. They were organized in guilds and as they trained, they worked their way up through the guild system from apprentice to master.

A master mason or a master carpenter was a skilled and respected artisan. In addition to working with his hands, he was an organizer and a supervisor and in many respects was the equivalent of the contractor of today. The different trades tended to work side by side. Labourers, carters and boatmen provided much-needed unskilled labour.

This tradition of organization was transferred to early Canada, particularly to New France. The first two centuries of settlement reinforced the medieval system. Even the value of skills being passed from generation to generation was found in New France. Noel Levasseur founded a remarkable dynasty of carvers. Jean Baillargé was an artisan whose offspring dominated architecture and the building trades for nearly two centuries (Ritchie).

Skills were passed on in this way through families and by apprenticeship. In addition, schools were founded to teach skills. Bishop Laval established a vocational school (the École des arts et métiers) at St-Joachim, near Quebec City, to provide instruction in "carpentry, sculpture, painting, gilding for church decoration, masonry and woodworking." Founded in 1668, the school had a second branch, primarily devoted to architecture, connected with the Seminary at Quebec City. Artisans connected with the school at St-Joachim include celebrated mason Claude Baillif and painter-decorator Frère Luc.

Early builders in British North America came from their mother country with similar skills. Many carpenters and joiners were among the Loyalists who arrived in Nova Scotia and Upper Canada from the United States, whereas the masons who arrived in Canada were predominantly from Scotland. French-Canadian craftsmen also worked in Upper Canada – particularly along the St. Lawrence – in the early years of the 19th century. They spread Quebec building techniques into the younger province.

2.2 THE BUILDER-CONTRACTOR

In the late 17th century and early 18th century in New France, certain craftsmen expanded their services and became builder-contractors, assuming responsibility for all of the tasks involved in erecting a building. Often, but not always, it was a stonemason who took on this larger role. The contractor would provide materials, employ a foreman (commis) and labourers and subcontract work to specialized trades. Some developed their businesses into large enterprises which had multiple projects underway simultaneously, much the same as general contractors do today.

The contractor entered into a legal contract with the property owner and provided a statement of work to be done (devis des ouvrages). The contract might be payable by fixed price (marché en bloc) or by piecework (à la toise).

The leading builder-contractors became skilled professionals with a solid grasp of their trade. Their education was gained from books and illustrations as well as from job experience. Several Quebec contractors of the period possessed standard French architectural treatises (see 6.2 below). They were capable of drawing plans and often styled themselves "architecte."

A celebrated practitioner of this type was Claude Baillif, who arrived in Quebec City in 1675 and was active as a mason, plasterer, designer and builder until shortly before his death in 1698. A 1679 contract describes him as an "architect and plasterer." In the next dozen and a half years he was contracted to build some 40 buildings, many of which he was credited with having designed. During this period, records show that he retained 27 workmen and more than half the masons in Quebec City as apprentices. (The overlap between contractors and architects is further discussed in 3.1 below).

Carpenters and masons often evolved into contractors in Upper Canada as well. The names of several builders in early York (Toronto) and in other communities have come down in the records.

By the middle years of the 19th-century, contracting firms had been established in many centres across the country. It is interesting to note that I.G. Baker and Company of Fort Benton, Montana, was contracted to build a number of structures during the developmental years of the Canadian Prairies, including several posts for the North West Mounted Police (e.g. Fort Calgary).

General contractors, as we know them today, are products of the 20th-century. As building components came to be fabricated in the factory rather than on site, it took new managerial skills to co-ordinate the suppliers and assemble a building from its components.

2.3 SUPPLIERS AND MANUFACTURERS

In earlier eras, building materials were produced in conjunction with the erection of a particular building. Trees would be felled and the timbers would generally be hewn on site. The finishing materials were likewise produced by the artisans involved in building, whether on the site or (for example, in the case of joiners) in their own workshops.

The various technologies gradually became more specialized. Individual entrepreneurs produced and sold supplies on the market. Sawmills produced lumber, forges manufactured nails and glassworks made window glass. These and other materials were sold by both manufacturers and retailers. A retail distribution network of lumber yards and hardware merchants grew along with the country.

A third stage of development was the mass production of finished work: cabinetry, mouldings, metalwork and other components could be ordered from catalogues or over the counter.

3.0 THE DESIGN PROFESSIONS

3.1 THE ARCHITECT

The emergence of the architect as a professional, distinct from the mason and the carpenter, occurred in Renaissance Europe. This new perception was inspired by the respect for the liberal (intellectual) arts and the recognition of the personality of the artist. L.B. Alberti defined the nature of the architect in his treatise of 1485:

> … it will not be improper to explain what he is that I allow to be an architect: for it is not a Carpenter or a Joyner that I thus rank with the greatest Masters in the other Sciences; the manual Operator being no more than an Instrument to the Architect. Him I call an Architect, who, by a sure and wonderful Art and Method, is able, both with thought and invention, to devise and with execution to compleat all those works, which, by means of the movement of great Weights and the conjunction and amassment of Bodies, can with the greatest Beauty, be adapted to the uses of Mankind and to be able to do this, he must have a thorough insight into the noblest and most curious Sciences. Such must be the Architect. (Jenkins, pp. 40-41).

The Renaissance architect achieved a position of being able to dictate to and hence, supervise the tradesmen, whereas master masons and master carpenters worked side by side as

equals and rarely instructed each other. A corollary responsibility of the architect, if implied, was as a teacher and disseminator of ideas.

The term "architect" was used in New France in the 18th-century to describe selected designer-builders. Jean Maillou, Quebec City-born and trained as a stone-cutter, was referred to as a "master mason" in 1702; fourteen years later the city census calls him "architecte," and in 1719 he was described as "Royal Architect" (architecte du roi). Subsequently he was called "architect and contractor for the King's buildings" and "overseer ('grande-voyer') of all New France" (Briggs).

The title of "Royal Architect" was bestowed on some practitioners for their perceived skills and as a measure of patronage and not for their formal education, as the equivalent ranks of Maillou and French-born and trained engineer Chaussegros de Léry would indicate. The honour was, as may be expected, derived from France. The idea of official royal patronage for artisans may be traced back at least into the 15th century: for example Jean Fouquet was "peintre du roi." By the 17th century, the title was common for architects: some, such as Louis le Vau, were styled "premier architecte du roi," whereas others, such as Antoine le Pautre, were merely called "architecte ordinaire du roi." In a ruling of the Académie royale d'architecture (founded in 1671) of 10 February 1676, the title "architecte du roi" was conferred on all members of the Academy and "masons, contractors and others engaged in buildings" were relieved of this privilege. This made an official distinction between architects and builders and extended beyond those who benefited from royal patronage. It was to be some time before this discrimination reached the New World.

In England the architectural profession emerged in the 17th century as a product of the taste of the Stuart court. Many architects found positions in the Office of Works (founded in 1768) – a type of equivalent to the Royal Academy of Architecture in France. An 18th-century architect would learn his profession by being "articled" to an architect at the age of 16 for a five- or six-year apprenticeship. He would attend lectures given by the Professor of Architecture at the Royal Academy and then travel to Europe and Italy for two or three years. About age 25 he would return to England and be equipped for private practice.

The perception of the differences between architects and builders is evident in this interrogation of Daniel Asher Alexander, which likely occurred in 1818:

"You are a builder, I believe?"
"No sir; I am not a builder; I am an architect."
"Ah well, builder or architect, architect or builder – they are pretty much the same, I suppose?"
"I beg your pardon; they are totally different."
"Oh, indeed! Perhaps you will state wherein this difference consists."
"An architect, sir, conceives the design, prepares the plan, draws out the specification – in short, supplies the mind. The builder is merely the machine; the architect the power that puts the machine together and sets it going."
"Oh, very well, Mr. Architect, that will do. A very ingenious distinction without a difference. Do you happen to know who was the architect of the Tower of Babel?"
"There was no architect, sir.
"Hence the confusion."

The tendency toward distinguishing a professionally trained architect from the tradesman took hold in Canada in the 19th-century. Training was gained by apprenticeship with a practising architect, usually lasting five years. Instruction in drawing and other skills might be available from a Mechanics Institute or other local organization. Only after schools of architecture began to appear at the end of the century was a formal education available (see 6.3 below).

The professional associations (see 4.2 below) have consistently discouraged architects from also practising as contractors. Nevertheless, some have continued to do both, usually by remaining outside the mainstream of the profession and declining official certification.

3.2 THE ENGINEER

Civil and structural engineers have always been considered distinct from architects because of their technical knowledge of structures. The profession developed out of the work of military engineers, who designed fortifications; and from civil engineers, who designed bridges and roads. In France the latter were trained at the École polytechnique, which was founded in 1794 and existed separately from the École des Beaux-arts.

The most distinguished engineer in New France was J-G Chaussegros de Léry. He appears to have served in the French army as an engineer before his arrival in Quebec City in 1716. He was styled "Royal Engineer" ("Ingénieur du roi")

and fulfilled his official duties of designing military works and drawing maps, as well as producing designs for some non-military buildings. He wrote a *Traité de Fortifications* in 1714, but it was never published.

With the arrival of the British, the Royal Engineers (a military corps, also known as the "Sappers") assumed a particularly important role in the development of the country. In 1779, Lt. Twiss (subsequently Capt. Twiss), the commanding Royal Engineer in Canada, began work on four short military canals on the St. Lawrence River to allow navigation around rapids. The most celebrated canal-builder was Lt.-Col. John By of the Royal Engineers, responsible for the construction of the Rideau Canal in the 1820s. By mid-century the Royal Engineers had built locks at Sault Ste. Marie and the Welland Canal, creating an integrated transportation system through early Canada.

Later in the century, the Royal Engineers were particularly active in British Columbia. A detachment of 165 men under the command of Col. R.C. Moody accomplished projects which ranged from the laying out of the capital at New Westminster (1859) to the building of a portion of the Cariboo Wagon Road (under Capt. John Grant).

Other engineers, who worked outside the military, were primarily employed by the government and railways. Samuel Keefer, born in Upper Canada in 1811, designed the first suspension bridge in Canada (over the Ottawa River, between today's Ottawa and Hull, in 1843) and the first railway tunnel in Canada (at Brockville, in 1860). Sir Casimir Gzowski was engaged on canals, roads and bridges and built the Grand Trunk Railway line from Toronto to Sarnia.

The distinction between engineer and architect sometimes became blurred. Chaussegros de Léry, for instance, produced a design for the Church of Notre-Dame in Montréal (Ritchie, p. 362) and the Royal Engineers designed St. Mark's Church at Fort Douglas, B.C. Until recently the professional associations discouraged architects and engineers from sharing a practice.

3.3 OTHER PROFESSIONS

In Europe, the time-honoured profession of surveyor preceded that of architect. The surveyor or overseer (the words mean the same: the first derives from Latin and the latter from Anglo-Saxon), was an official who inspected buildings to ensure their safety. The title became increasingly associated with positions of importance. In England, the Surveyor-General of H.M. Office of Works held a very prestigious position; its incumbents included Inigo Jones and Sir Christopher Wren.

This particular meaning of the term disappeared in the 19th century. The terms "architect" and "surveyor" were synonymous by the 1820s and the former emerged in common use. The modern usage of "surveyor" is as a "measurer" – either one who measures the land (a land surveyor) or one who measures quantities of building materials (a quantity surveyor).

Land surveyors were a prestigious group in Canada long before architects and engineers had professional organizations or certification, probably because of the importance of land division to the settlement of Canada. The Dominion Land Survey was established in 1871 to survey the western territories acquired from the Hudson's Bay Company. The Geological Survey of Canada was founded in 1842.

A number of architects also worked as patent attorneys. In this capacity, they prepared drawings for patent applications. Ottawa architects Adam Harvey (in the 1890s) and W.E. Noffke (in the early 1900s) were two of the many practitioners who styled themselves as "architects and patent attorneys."

4.0 PROFESSIONAL ORGANIZATION

4.1 CRAFT GUILDS AND TRADE UNIONS

Guilds and unions are responsible for training tradespersons. Their organizations affect the skills that are available in the workplace and ultimately, the built form.

Great Britain and France developed elaborate guild systems that protected the quality and integrity of traditional crafts. Young men were indentured (or articled) as apprentices for a fixed period of time before becoming qualified practitioners, initially as journeymen and, subsequently, master craftsmen.

In England, the period of apprenticeship was generally seven years. Trades that observed this system included bricklayers, masons, and carpenters. This craft organization was evident in both New France and British America. For example, Jean Maillou is documented as having taken apprentices, providing them with room and board and paying them a nominal fee; however the organization did not have the maturity of development found in Europe. The city companies developed in some American regions; the Carpenters' Company of the City and

County of Philadelphia, for instance, was a strong organization that has survived nearly three centuries.

Early in the 19th century, Canadian craft unions began organizing skilled workers. An early union was the Amalgamated Society of Carpenters and Joiners. Isolated strikes for higher wages or improved working conditions began to occur in the 1830s. Unions have worked to raise standards and have developed increasingly stringent regulations controlling such issues as tools, apprenticeship and workload. Many of these have been adopted by employers and become standard rules.

From time to time efforts have been made to organize informal guilds or associations that might improve the quality of crafts and trades. The most notable in our century has been the Guild of All Arts, founded in 1932 by Spencer and Rosa Clark in Scarborough, Ontario. Practitioners of the constructive and decorative arts, as well as theatre and music, worked and lived at the Guild in "pleasurable conditions." The model for this kind of community may be found in the guilds and artistic associations formed as part of the Arts and Crafts Movement in England, such as C.R. Ashbee's Guild of Handicraft (begun in 1888).

4.2 PROFESSIONAL ASSOCIATIONS

Most professions have organized associations to look after their needs. Their objectives include the regulation of practice through measures such as enforced certification, establishing educational standards; and the exclusion of persons perceived as lacking appropriate credentials or training.

The Académie royale d'architecture in France (founded in 1671) and the Royal Academy in Britain (founded in 1768) were early formal associations of architects. Professional societies organized by the practitioners themselves were quick to follow. Britain gave birth to the Society of Civil Engineers (1771), the Institution of Civil Engineers (1818) and the Institute of British Architects (1834; called the Royal Institute of British Architects since 1866). These associations were mainly interested in improving the quality and status of their professions. The Institute of British Architects stipulated that to be eligible for membership, no architect might receive "any pecuniary consideration or emolument, from any builder or other tradesman whose works he may have been engaged to superintend; or having any interest in, or participation with any trade, contract, or materials supplied at any works, the execution whereof he may be or have been engaged to superintend..." (Jenkins, p. 118). Two other British associations, the Surveyors' Club (1792) and the Society of Architects and Surveyors (1834), were less exclusive in their approach.

Architects in Upper Canada followed these examples in the middle of the last century. The Canadian Institute was organized in 1849 as an association of architects, engineers and surveyors. It soon developed broad eductional aims beyond those of the professional needs of its members. Consequently the Association of Architects, Civil Engineers and Public Land Surveyors was formed in Toronto and the Association of Provincial Land Surveyors and Institute of Civil Engineers and Architects in Ottawa, both in 1859. They merged three years later but then seemed to have dissolved.

The first lasting architectural society was the Ontario Association of Architects (OAA), founded in 1889 and still an important organization. It developed out of the Architectural Guild established by a group of Toronto architects in 1887. At the first annual convention, president W.G. Storm urged that the OAA seek guarantees that architects would be trained properly so that the public would be "protected from incompetent and unscrupulous practices." The Province of Quebec Association of Architects was formed in 1890. All other provinces formed their own associations in the years that followed. A national group, the Royal Architectural Institute of Canada (RAIC), was organized in 1907 and chartered in 1909.

Only members of provincial associations are allowed to practise architecture and call themselves architects. This privilege is ensured by provincial legislation. Unauthorized persons who call themselves architects are liable to prosecution.

The other building professions have also organized into associations. The surveyors preceded the architects: the Association of Dominion Land Surveyors was formed in Manitoba in 1882 and the Association of Provincial Land Surveyors of Ontario in 1886.

Engineers first organized as the Engineering Institute of Canada in Montréal in 1887. Two years later it became the Canadian Society of Civil Engineers and this in turn was renamed the Engineering Institute of Canada in 1918. Since that time, associations have been formed in every province.

The Canadian Society of Landscape Architects and Town Planners was founded in 1934. The landscape architects subsequently separated themselves from town planners and became the Canadian Society of Landscape Architects. The Central Chapter of the C.S.L.A. became the Ontario

Association of Landscape Architects in 1960. It gained legal status in 1984 as the regulator of the profession in that province, much as the architects had nearly a century earlier. At present five provinces or regions have associations.

Founding Dates of Principal Organizations

Canadian Institute	1849
Association of Architects, Civil Engineers and Public Land Surveyors	1859
Association of Provincial Land Surveyors and Institute of Civil Engineers	1859
Association of Dominion Land Surveyors	1882
Association of Provincial Land Surveyors of Ontario	1886
Architectural Guild	1887
Engineering Institute of Canada	1887
Ontario Association of Architects	1889
Canadian Society of Civil Engineers	1889
Province of Québec Association of Architects	1890
Royal Architectural Institute of Canada	1907
Engineering Institute of Canada	1918
Canadian Society of Landscape Architects and Town Planners	1934
Ontario Association of Landscape Architects	1960

5.0 BUILDING REGULATION

Most authorities regulate building through a series of acts, codes and regulations. Building codes, fire codes and occupancy and maintenance bylaws are intended to protect the health and safety of occupants by ensuring safe construction; protection of buildings from fire, collapse from earthquakes and other such traumas and proper maintenance. Zoning and planning legislation are intended to ensure the orderly development of communities. Buildings are also regulated by various acts that control specific building types or services, such as liquor-licensing acts and theatre regulations. Standards directed at certain building services and materials exert further control.

All of these kinds of regulations have been effective in dictating certain building features and therefore they have been potent factors in the diffusion of design and technical developments. For example, a law passed in Montréal in 1721 required that houses be built of stone to prevent the spread of fire. This consequently led to the development of a significant school of masons and an important regional building type. In a similar way, the current building code regulation limiting combustible construction to buildings of three or fewer storeys has led to the common low-rise multiple dwelling of today, just as the adoption of setback requirements in zoning by-laws produced the stepped highrise tower of the 1920s and the slab tower of the 1960s.

5.1 BUILDING CODES

The need for the regulation of building was appreciated in the cities of 17th- and 18th-century New France (Quebec City, Montréal and Louisbourg). Commencing in 1673, Governor Frontenac insisted on a formal approval process for street alignments, house alignments and common walls and gables ("pignon mitoyen"). In addition, the *Costume de Paris* (written in 1510, introduced into New France in 1627 and the colony's only legal code) provided some regulations for buildings, particularly those (such as firebreaks) that protected buildings against the threat of fire (Castelli, pp. 413-26).

Fires nevertheless continued to occur. A major fire on 19 June 1721 destroyed more than 130 buildings in Montréal and led to the passing of an ordinance forbidding anyone to build a house in towns and large villages, where stone is easily found, except in stone.

It further stipulated that all houses be at least two storeys tall. This became a precedent for a "ruling on the construction of houses in fireproof materials in the towns of the colony, 7 June 1727," which was Canada's first comprehensive building code. Several clauses directly influenced building form, including a prohibition against "curb-roofs (mansards) ... which burden the buildings with forests of wood," and a requirement that there be fire-break gables, described as:

> ...internal partitions which extend beyond the roofs and divide them into several sections or separate them from neighbouring houses, so that fire is less likely to spread from one to the other (Maison, p. 82).

For many years following, building codes remained a municipal responsibility. This caused considerable diversity from community to community and, as recently as the 1930s, many areas had no building regulations at all. To promote uniformity, the National Building Code of Canada was published in 1941 under the direction of the National Research Council. The National Building Code has no legal status unless specifically

adopted by an authority, but nevertheless has had an intended major unifying influence on building code requirements. In the 1970s, most provinces assumed jurisdiction over building codes and adopted regulations based on the National Building Code. Although there are exceptions, the general practice now is that building codes and regulations are enacted by the provinces and administered by municipalities.

The National Fire Code was first issued by the National Research Council in 1963. It has been adopted or referred to by many provincial and municipal authorities over the past decade.

Building codes have generally been directed at new construction. Only recently have specific amendments and addenda been made in some codes to accommodate the special needs of rehabilitation and restoration. Part 11 of the Ontario Building Code, enacted in 1983, created a precedent regarding residential renovation.

5.2 PLANNING LEGISLATION

Planning legislation is concerned with controlling change and development. Zoning, an important class of planning regulation, is a municipal responsibility and is enabled by provincial legislation. It controls such matters as land use, height, density, setbacks and massing. Canada's first zoning bylaw was passed in Point Grey, British Columbia (now a part of Vancouver) in 1922; Kitchener, Ontario followed in 1924.

Long before these formal bylaws came into effect, some municipalities regulated planning matters. Governor Simcoe of Upper Canada enacted early zoning regulations in 1793. As Kingston merchant Richard Cartwright described somewhat disapprovingly to a friend:

> You will smile perhaps when I tell you that even at York, a Town Lot is to be granted in the Front Street only on Condition that you shall build a House of not less than 47 Feet Front, two Stories High & after a certain Order of Architecture; in the second Street, they may be somewhat less in Front, but the two Stories mode of Architecture are indispensible; and it is only on the back Streets and Allies that the Tinkers and Taylors will be allowed to consult their own Taste and Circumstances in the Structure of their Habitations upon lots of 1/10 of an Acre. Seriously, our good Governor is a little wild in his projects (Arthur, pp. 30-31).

Zoning has a powerful effect on building form and has contributed to the diffusion of Canadian building types.

6.0 DIFFUSION OF SKILLS

Organizations and systems have developed for many reasons, perhaps the most important of which is the diffusion of skills among their memberships and their audiences. The organization of trades and professions provided an infrastructure which spread knowledge and developed technical schools. The members of these professions, in turn, became a market for whom books, periodicals and educational programs were produced. This section looks briefly at the various means by which skills were diffused throughout the country.

6.1 APPRENTICESHIP

As has been mentioned above, both tradesmen and architects traditionally learned their trades through apprenticeship with a master in their chosen field for between five and seven years. Aspiring architects might enter the office of an established architect either as a pupil (in which case he paid a premium to the architect at the beginning of his period of training) or as an apprentice (where his payment was in kind by his services). Barrington Kaye has analysed the training undergone by 19th-century British architects listed in the *Dictionary of National Biography.*

No such analysis has been made for Canadian architects, but reading the biographies of 19th-century practitioners suggests a similar pattern, although with the expected time lag. Apprenticeship to a builder or a master tradesman was prevalent until the early years of the 19th century and apprenticeship to an architect became common thereafter. Certain firms attracted more apprentices. A proportionately large number of young architects passed through the Toronto office of William Thomas (subsequently William Thomas and Sons) during the middle years of the last century. Some architects were untrained but talented amateurs; two who stood out in the 19th century were the German-Canadian Whilhelm Berczy and the Quebec priest Pierre Conefoy.

The situation changed toward the end of the century when schools began to offer formal training in architecture. (See 6.3 below).

Year in which the architect reached age 20	pre-1789		1790-1819		1820-1849		1850 ff	
Form of training	No.	%	No.	%	No.	%	No.	%
Apprenticed to a builder	3	7	11	12	5	5	0	0
Apprenticed to an architect	17	39	56	63	71	76	35	78
Trained for another occupation	3	7	5	6	5	5	0	0
Other architectural training (e.g. private study, travel)	8	18	14	16	2	2	7	16
No details	13	30	3	3	11	12	3	7
	44	100	89	100	94	100	45	100

(Kaye, p. 51)

6.2 PUBLICATIONS

Publications have always provided an important medium for disseminating ideas on architecture. Four kinds of publications have been particularly important: architectural treatises, architectural periodicals, pattern books and technical manuals.

Architectural treatises appeared in Europe during the Renaissance and post-Renaissance period. Both French-speaking and English-speaking architects in early Canada would have been well versed in the writings of the masters of their profession. The leading French treatises (and the date of their earliest editions) were those by Philibert de l'Orme (1657), François Blondel (1675), C.A. Daviler (1691) and J.F. Blondel (1752). The most respected English works were by John Shute (1563), James Gibbs (1725), Isaac Ware (1756), Sir William Chambers (1759) and Joseph Gwilt (1842). Both the French and the English architects would likely have read translations of the time-honoured treatises by the Italians Alberti, Serlio, Vignola and Palladio.

Most of these treatises were modelled to some extent on the treatise written by the Roman architect Vitruvius some time before 27 B.C. and which was known through innumerable manuscripts, publications and translations. Vitruvius' *Ten Books of Architecture* were devoted to general architectural principles, studies of the orders, discussions of particular building types and notes on mechanical and military engineering.

Copies of the European treatises were found in the libraries of many Canadian architects. Although book learning could never replace first-hand training by an architect, it could supplement the inadequacies of the education system in the New World.

Architectural periodicals began to appear with some regularity in Europe and America in the middle of the 18th century. They combined articles on techniques and practice with descriptions and illustrations of recent projects, similar to architectural magazines of today. *The Builder* (begun in 1842) was certainly the most influential British publication and *American Architect and Building News* (begun in 1876) led the way in the United States. Canada soon followed suit. *Canadian Builder and Mechanics' Magazine* made a short-lived appearance circa 1865 and *Canadian Architect and Builder* appeared in 1888 and made a significant impact until it merged in 1908 with *Contract Record*. The Royal Architectural Institute of Canada began publication of its *Journal* in 1908 as well.

Perhaps the most influential of publications were the pattern books, which reproduced design models of buildings and details for others to copy or modify. These "builders' guides," as they were also called, began to appear in England in the 18th century; *Vitruvius Britannicus* and the many publications of Batty Langley are familiar to most historians of architecture. The 19th century released a rash of such

publications in both Britain and the United States. Some, like John Claudius Loudon's *Encyclopedia of Cottage, Farm and Villa Architecture and Furniture* (1833) and the various publications of Asher Benjamin, such as *The American Builder's Companion* (1826) and Andrew Jackson Downing, for example *Cottage Residences* (1842), were thoughtful and substantial books which appear to have had a major impact on Canadian architects. Many others were more hastily prepared by builders with lesser design skills; nevertheless, they answered the need of the rapidly expanding continent for easy-to-copy models. Among the many American publishers and authors whose books of plans for sale flooded the Canadian market were the Radford Architectural Company and Robert W. Shoppell.

Canadians followed with their own pattern books. Prolific Canadian author Fred Hodgson, who combined technical treatises with plan selections, published most of his material through a Chicago firm. Individual building types were often the focus of these books, for example, J. George Hodgins, *The School House, its Architecture* (1857, 1876); and the Committee on Church Architecture of the Presbyterian Church in Canada, *Designs for Village, Town and City Churches* (1892). Most prevalent were those with designs for houses and barns. Many were produced by the lumber industry in an effort to promote its products. The Western Retail Lumbermen's Association's *Plans for the Home Builder* (1926; also earlier books from 1915) issued plans and elevations of buildings that can be identified in built form all across the Prairies. Retailers sold plans, materials and even prefabricated buildings: the T. Eaton Company's *Plan Book of Ideal Homes* (1919) and the B.C. Mills Timber and Trading Company's *Catalogue of Patented Ready-Made Houses* (1905) found a solid market.

The effect of these many publications was to allow any skilled builder or "handyman" to build a perfectly acceptable house from a large repertoire of types and models. This was a needed amenity in a young country with a shortage of trained architects.

6.3 FORMAL EDUCATION

Formal education has been available for the building trades since the formation in 1668 of the vocational school at St-Joachim, cited in 2.1 above. It was followed by a school established by Quévillon at St-Vincent-de-Paul. Few developments occurred until the 19th century, with the establishment of a series of Mechanics' Institutes across the country. The ones in Toronto (formed ca. 1831) and St. John's (1839) were the earliest; similar institutes were subsequently begun in most major cities. The Mechanics' Institutes taught trades, mechanical skills and drawing and often had reference libraries.

Design was first taught by the Ontario Society of Artists organized in Toronto in 1872. This led to the founding of the Ontario School of Art in 1876 and the Royal Canadian Academy in 1880.

The first university department of architecture was at McGill University, established in 1896. The first director was Professor Stewart Henbest Capper; he was succeeded by Percy Erskine Nobbs in 1903. The University of Toronto had earlier been offering courses in architecture through its School of Practical Science (i.e. engineering). The two followed many aspects of the curricula of Columbia and Massachussetts Institute of Technology, which was much influenced by the École des Beaux-arts in Paris. An École des Beaux-arts was established in Montréal in 1922; it included a school of architecture which amalgamated with the Université de Montréal in 1968.

Only five Canadian universities offered architectural degree programs in 1945; this had increased to ten in 1984.

In the first half of the 19th century, engineers were trained as apprentices to professionals. The two largest offices were those of Samuel Keefer and Sir Casimir Gzowski. The University of Toronto established a chair of civil engineering in 1851. The first engineering school in Canada was opened in 1854 at King's College in Fredericton, now the University of New Brunswick. By the 1870s there were two schools in Montréal and one in Toronto offering formal instruction in applied science.

7.0 BIBLIOGRAPHY

The following bibliography includes both works that were helpful in the preparation of this volume and general studies that were not consulted in depth, but which will form useful sources for persons wanting additional information on a specific topic. Annotations have been prepared for many of the entries in the former category, but not those in the latter.

Arthur, Eric. 1986. *Toronto: No Mean City*. 3rd ed., rev. by Stephen A. Otto. University of Toronto Press, Toronto.
(Appendix A: The Architectural Profession in the Nineteenth Century, pp. 237-41.)
An overview of the development of the architectural profession in Ontario, particularly in Toronto.

Blue, Frances. n.d. "History of the Canadian Society of Landscape Architects." Unpublished manuscript. Aurora, ON.

Briggs, Martin S. 1974. *The Architect in History*. Da Capo Press, New York.

Canadian Encyclopedia, The. 1985, James H. Marsh, ed., 3 vols. Hurtig, Edmonton.
Many articles have been consulted, including "Architectural Practice," "Architecture, Development," "Building Codes and Regulations," "Craft Unionism," "Engineering," "Education, Technical," "Urban Design," and entries on individual practitioners.

Castelli, M.D. 1975, "L'Habitation urbaine en Nouvelle-France," *Cahiers de Droit*. Vol. 16.

Colvin, Howard. 1978. *A Biographical Dictionary of British Architects 1600-1840*. John Murray, London.
Introduction: The Practice of Architecture, 1600-1840. I: The Building Trades. II: The Architectural Profession, pp. 17-41.
An excellent survey of the development of the building trades and the architectural profession in Britain.

Fortier, Yvan. 1980. *Menusier charpentier: Un artisan du bois à l'ère industrielle*. Boréal Express/Musée national de l'Homme. Montréal.

Gotch, J.A., ed., 1934. *The Growth and Work of the R.I.B.A. 1834-1934*. Simson & Co., London.

Gowans, Alan. 1955. *Church Architecture in New France*. University of Toronto Press, Toronto.

Hitchcock, Henry-Russell. 1962. *American Architectural Books*. University of Minnesota Press, Minneapolis.

Hutchinson, Sidney C. 1968. *The History of the Royal Academy 1768-1968*. Chapman and Hall, London.

Jenkins, Frank. 1961. *Architect and Patron*. Oxford University Press, London.
Quoted material is printed with permission.

Journal of the Royal Architectural Institute of Canada. 1962. "Brief History of the RAIC," (December). Ottawa.

Kaye, Barrington. 1960. *The Development of the Architectural Profession in Britain*. George Allen and Unwin, London.
A detailed account of the development of the architectural profession.

Kettle, H.G. 1940. "The Canadian Handicraft Movement," *The Canadian Forum*, Vol. 20. Toronto, pp. 112-14.

Kostof, Spiro, ed. 1977. *The Architect*. Oxford University Press, New York.

Marsan, Jean-Claude. 1981. *Montréal in Evolution*. Fides, 1974. McGill-Queen's University Press, Montréal.
Published in French as *Montréal en évolution*. Montréal. Consulted for its discussion of early building regulations in Montréal.

Mills, Edward. 1991. *Buying Wood and Building Farms: The Marketing of Lumber and Farm Building Designs on the Canadian Prairies Between 1880 and 1920*. Environment Canada, Parks Service, Ottawa.

Moogk, P.N. 1977. *Building a House in New France*. McClelland and Stewart, Toronto.
A well-researched account of the activity of building in New France, including discussions of building regulation and the practices of contracting and architecture.

__________ 1983. "A Note on the Association of Architects, Civil Engineers and Public Land Surveyors of the Province of Canada." Unpublished manuscript.

Moss, Roger W., Jr. 1972. *Master Builders: A History of the Philadelphia Building Trades*. Self-published.

__________. *1976*. "The Origins of the Carpenters' Company of Philadelphia," in Charles E. Peterson, ed., *Building Early America*. Chilton, Radnor, PA, pp. 35-53.

Ontario Association of Architects. 1950. *The Ontario Association of Architects 1890-1950*. University of Toronto Press, Toronto.

Ritchie, T. 1967. "The Men Who Did It," in *Canada Builds 1867-1967*. University of Toronto Press, Toronto, pp. 361-75.
An overview of the development of the building trades and the architectural and engineering professions, particularly in Ontario and Quebec.

Royal Architectural Institute of Canada. 1966. *Survey of the Profession*. Committee on the Profession. Ottawa.

Saint, Andrew. 1983. *The Image of the Architect*. Yale University Press, New Haven, CT.

Tausky, Nancy Zwart, and Lynne Delehanty DiStefano. 1986. *Victorian Architecture in London and Southwestern Ontario: Symbols of Aspiration*. Chapter 2: The Architect in Victorian Canada. University of Toronto Press, Toronto, pp. 57-107.
A detailed account of the practice of architecture in 19th-century Ontario, including discussions of training and publications.

Thomson, Don W. 1967. *Men and Meridians: The History of Surveying and Mapping in Canada*. Department of Energy, Mines and Resources, Ottawa.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

2
PERIOD SITE WORK

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

Period site work involves landscape activities that alter the natural physiographic patterns and ecology of an area. Site work is usually associated with property development. It is frequently preparatory in nature and allows for the introduction of structures and facilities, or for changing the patterns or capability of a system as, for example, adding tile drainage to allow for more intensive use.

Period site work includes survey and site development, layout, earthwork and grading, planting material and circulation and paving. It may also include bringing amenities to a site or introducing them onto the site, e.g. construction of a well or the installation of a road.

Site work is the tangible manifestation of human actions within the natural landscape of a definable area. The broader pattern that dictates site development overlaps with period landscape. For example, the seigneurial system in Quebec, with its ribbon pattern of land subdivision, provides a framework for circulation, cluster arrangement of buildings, field layout, boundaries and vegetation patterns.

Only after documenting and analysing these features within their historic context can one determine whether or not a landscape has changed from the period from which it derives its significance.

Period site work involves management and site improvement. Site work is usually a significant capital expense and results in major changes to the site. Period landscape, which is discussed in Section 14, is an extension of site work.

1.1 DEFINITION

A period site is a place that has been settled, controlled or manipulated for generations. It is a geographically definable area possessing a significant concentration, linkage or continuity of landscape components that are united by human use and events or aesthetically by plan or physical development.

Period site work deals with site-related trades and how practice has been instrumental in shaping a landscape. Historic or contemporary technical drawings including clearing, grubbing, grading plans, utility layouts and plans for the location of buildings and for the circulation network, are the conventional means of recording this system.

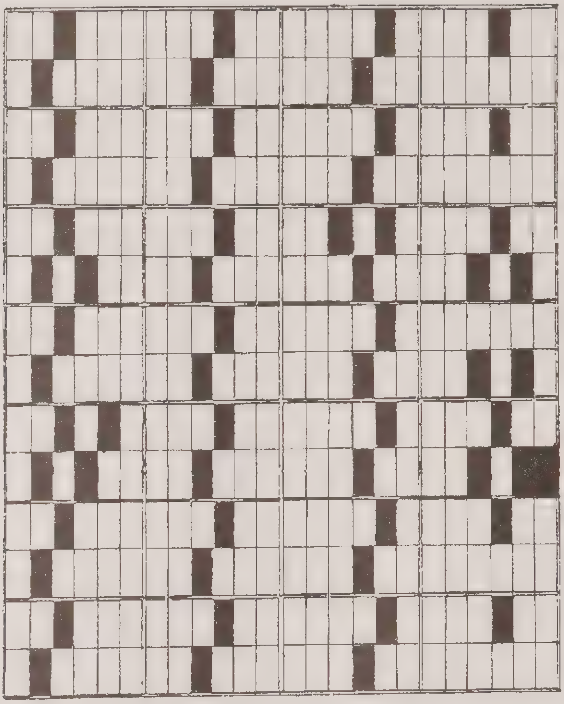
The components and the period construction procedures that produced them together document the resource as a period feature and allow for its conservation.

2.0 LAND SURVEYS AND SITE DEVELOPMENT

Site development is affected by broad planning issues and the large-scale relationship among major components and predominant land forms, features, vegetation or natural barriers. Site clusters, field patterns, earthworks and military battlements, canals and waterways are the land-use activities that were superimposed onto the natural landforms. The physical forms encouraged and dictated site development.

Maps, land surveys and legal descriptions provide a record of the imposition of a formal arrangement on the wilderness. For example, *Ontario's History in Maps* documents the survey patterns by which Upper Canada was settled. The basic unit of the survey was the township, divided into concessions and lots with provision for roads. This system of land survey, derived from basic procedures set down by the Crown in 1763, forms the basis of land subdivision and organization of the road system and layout of towns and cities. Only where natural features presented obstacles did the plan deviate.

The character and form of the southern Ontario landscape developed largely as a result of early land surveys and the concomitant road patterns which emerged. The earliest survey of Upper Canada was issued in September 1783. Five townships in the Bay of Quinte area were surveyed in 1783-84 and were opened for settlement by United Empire Loyalists in 1784. These early surveys disregarded natural landscape features and provided instead a system of rectangular or square lots, divided by roads. Seven different systems of township surveys were adopted from 1783 to 1906, each based on a gridiron concept. These ranged from 100 acre (40 ha) to 1800 acre (727 ha) lots. By 1860, all of southern Ontario had been surveyed and settled. This planned subdivision of land remains today and gives the landscape of southern Ontario its major character and form. Subsequent development, landscape form, building siting, tree planting and smaller subdivision of land have been greatly influenced by the early gridiron surveys.



"Sketch of a Township of nine miles in front by twelve miles in depth, supposed to be situated on a River or Lake; laid out into Farm Lots of about 200 Acres each..." (Ontario's History in Maps).

3.0 LAYOUT AND GARDEN PLANS

Site layout includes the actual staking and arranging of items transposed from the plan to the site. The site arrangement is the internal placement of elements such as plant material, fences, paths and buildings within a discrete landscape setting.

The process of laying out a site took many forms, often depending on first locating the house and orienting it to views and to climatic factors. On small urban sites, the orientation of buildings, setbacks and treatment of yards was predetermined by municipal regulations, insurance requirements and tradition.

Often the process of laying out a rural site involved clearing. The removal of unwanted materials, whether structures, trees and shrubs or topographic features, is part of the site work. The process of clearing and of laying out a property is described in the writing of settlers such as John Langton who settled near Fenelon Falls, Ontario, and who wrote of his attempt to lay out his farm:

> As one goes on clearing for a year or two more one puts up a fence here and a fence there as suits ones crops best and the end is a farm with no two fences and no two buildings parallel. Now one sees ones way more clearly and as one is putting up more permanent buildings and fences one wishes to introduce something approaching to symmetry and regularity. Such was my case, last spring my farm being subdivided by fences pointing to 21 different points on the compass, not to mention the buildings. The first step towards dressing these disorderly ranks was to make an accurate survey and map where non parallelism of supposed parallel lines came [to sight] (Langton).

Landscape design was often treated in a pictorial fashion, with a property providing a three-dimensional arrangement. In the late 18th century, Humphrey Repton evolved a technique of rendering watercolours of his clients' properties in before and after views. These were done with fold-out sections of the sketches that dramatized the change to take place.

In Canada, topographic artists such as James Cockburn used the same rendered watercolour technique to illustrate the gardens of the Lieutenant Governors in the various provinces. Later, house-proud Victorians recorded their fashionable estates and landscaped properties in the county atlases available throughout Ontario, Quebec and the Maritimes.

Site plans, garden and landscape design, planted areas, types of gardens and field patterns are documented in a number of early publications such as *The Illustrated Annual Register of Rural Affairs* (1850). It described the laying out of farms:

> One of the most important parts of farm management, consists in the convenient and economical subdivision of farms into fields. It is the very foundation of systematic culture. A good rotation and a profitable application of labor, cannot exist in badly arranged and inaccessible lots. The following may be given as some of the most prominent points to be observed in planning subdivisions:

1. Fields to be of nearly equal size, so as to admit a rotation of crops.
2. A suitable number of fields, to allow the various crops to occupy each its own field.
3. The form to be nearly square, to save fencing material, unless the land varies in character.
4. Where the land varies much, a variation in boundaries so as to bring the same kind of soil into the same field, more especially if swamp and upland.
5. Placing the lane or farm road, so as to enter all the fields by as short a way as practicable.

4.0 CIRCULATION AND PAVING

Circulation networks range in scale from footpaths to highways. Networks may be internal to a landscape or they may connect that landscape to the surrounding area. This aspect of site work includes walks, roads, paths, terraces, edging and

Aerial Rendering of Townships between Lake Ontario and Lake Simcoe, North of York, ON.

other hard surfaces. For example, the Rideau Canal system is a circulation network and also defines landscape spatial organization, land patterns and settlement patterns.

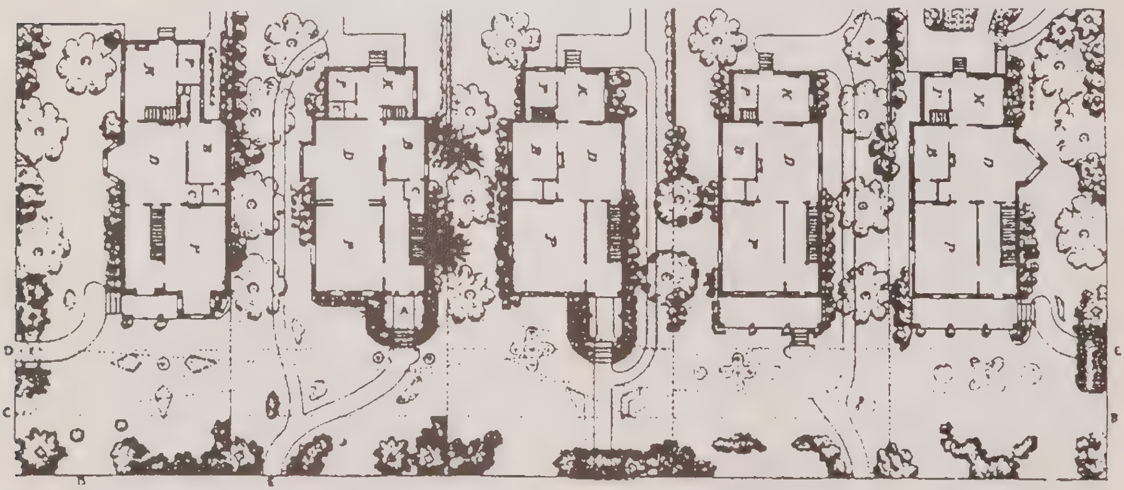
There are extensive documentary sources related to circulation. For example, an 1868 article, "Stone and Gravel Roads" urges the importance of constructing roads of uniform materials instead of soft earth or mulch:

> Could we but see the immense assemblage of broken and worn harnesses and sprained and lame horses (enough to fill a ten-acre lot) which the bad roads throughout the country annually occasion (*Illustrated Annual Register of Rural Affairs,* p. 187).

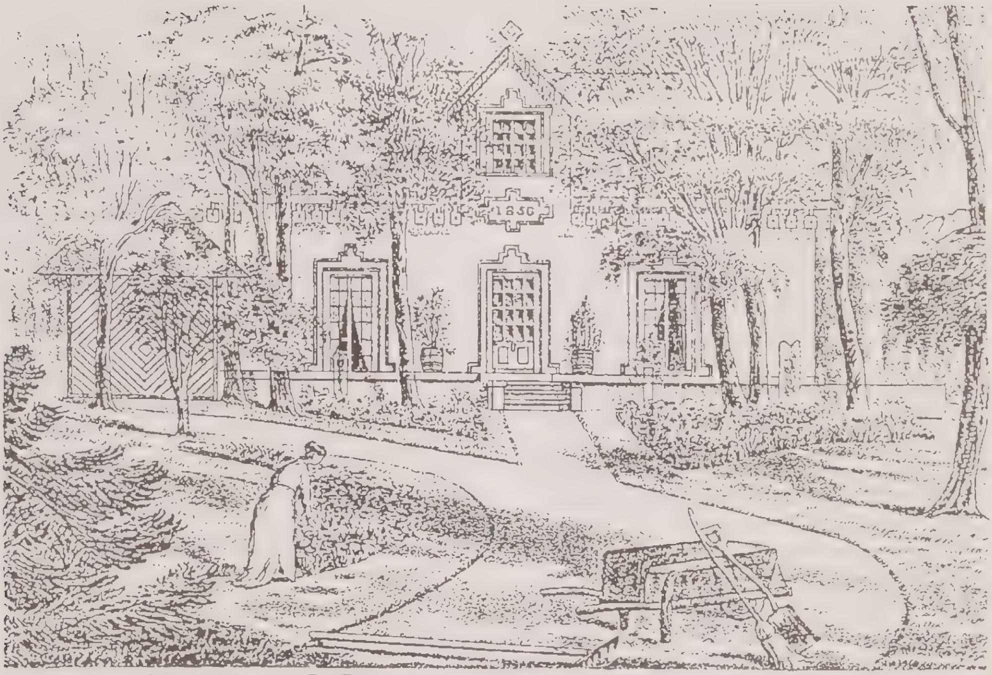
The article described the wrong way and the right way to build a road. It noted that it is common practice to draw the loose and scattered stones from the fields to form a bed of proper width, then cover this with gravel. The stones, however, due to frost action and the jolting of heavy wagon wheels, loosen and work their way up, resulting in an excessively rough road. A solution to the problem was given in the form of specific arrangements of stone by size and judicious use of gravel between them.

The following are excerpts from the *Kingston Chronicle*, 9 August 1822. These are standard specifications recommended by the Parliamentary Commission. They indicate the standards set for new road making:

> I. Shape of Cross Section
>
> *Rule 1* Upon a road of 30 feet in width the sides should be 9 inches below the surface in the middle. The best cross section is a segment of a flat ellipse: this shape not only assists the water to pass from the centre, towards the sides, but greatly contributes to the drying of the road, by allowing the action of the sun and air to produce a great degree of evaporation. Surveyors ought to use a level in giving roads a proper shape in order that the surface may be one uniform curvature, without the deviation from the prescribed line of the cross section.



A model suburban block designed in 1870 could easily be representative streets in parts of Sandy Hill, Ottawa, ON. Such features as flared sidewalks and lawns that extend between three and four properties are aspects of the art of beautifying suburban home grounds as featured in Victorian Gardens.



RESIDENCE OF D. FOWLER, ARTIST, AMHERST ISLAND ONT

Such illustrations depict layout and design of the garden and walks for both elaborate grounds as well as the more functional rural properties. H. Belden and Co., Atlas of the County of Carleton *(Toronto: 1879).*

II. Drainage

Rule 2 All ditches ought to be on the field side of the road fences and to be connected with the natural watercourses of the country. The stone drains and culverts, which cross under the road, should be numerous and continued through the fences into the ditches.

In order to keep a road perfectly dry, openings of mason work should be made from the side drains of the road into all these cross drains to carry off the water collected from the surface of it. The bottoms of the cross drains must be well paved, particularly, at these openings. It ought never to be forgotten, that in order to have the surface of a road perfect, it must be kept completely dry. All land springs ought to be carried from the site of the road by under-draining.

III. Trees and Fences

Rule 3 It is absolutely necessary to remove trees from the sides of roads and to keep the fences under five feet in height. No less than 20 per cent of the expense of repairing roads is incurred by the trees and the improper state of the fences, keeping the roads wet and by that means occasioning the rapid destruction of the materials.

IV. Materials

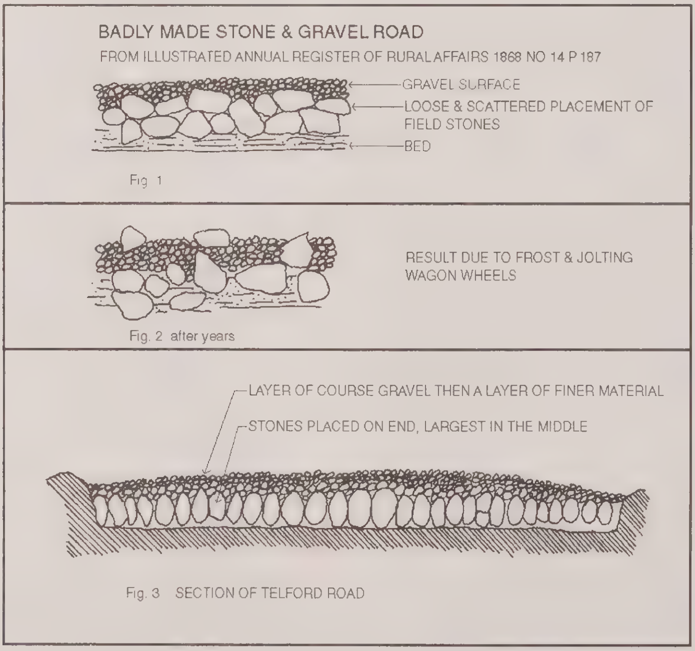
Rule 4 Where the materials are quarry or field stones, the hardest part of them only should be used. Each stone should be so broken that it may, in its largest dimensions, pass through a ring of two and a half inches in diameter. Hammers with slender handles light and well steeled, must be made on purpose

for breaking them. This work ought always to be done by measure, either at the quarries or in proper recesses, made for the purpose on the sides of the road. Men who are past hard labour and women and boys, may be employed upon the last operation, in breaking them small. When the materials consist of gravel, the stones only which exceed one and a half inch in size should be taken from the pits for the use of the middle part of the road. These ought to be raked together as the gravel is thrown up by the workmen. This process will, in most cases, save the expense of riddling and washing the gravel. All the smaller stones and gravel may be used for the sides of the road and the foot paths. The large gravel stones ought to be properly broken, either at the pits or in the aforesaid recesses. Surveyors should pay very particular attention to this rule, because the common use of a mixture of round gravel and clay is a public nuisance and must be got rid of. Where a surveyor obstinately persists in this practice, the trustee should dismiss him.

5.0 PLANT MATERIAL AND LANDSCAPING

Plant material and planting are basic to horticultural and landscape activities. Commercial nurseries and nursery stock were generally not available until the 19th century. However, the exchange and maintenance of plant material has been an important part of site work in Canada since the first settlement.

As early as the 1630s, Canadian plant material was being identified and shipped back to Europe. "Jardins du Roi" were established as holding or keeping gardens for native material brought from the wild for shipment to France. In 1635 the French botanist Jacques Cornuti published in Paris his book, *Canadensium Plantarium aliarumque nondum editarum historia* based on specimens sent to him by botanists in New France. Jesuit and other missionary organizations, besides collecting native flora, introduced and cultivated European plant varieties in New France in an effort to encourage the development of agriculture among native peoples and settlers.



Wrong and right ways to build stone and gravel roads. Illustrated Annual Register of Rural Affairs, *Albany, N.Y., 1868, p. 187.*

In the 18th and 19th centuries, the number of botanical expeditions and flora surveys reflected the intense interest in plant material for horticultural, medicinal and culinary uses. Such men as Swedish botanist Peter Kalm travelled extensively in Canada. His 1747 journal provides excellent documentation of Canadian flora and descriptions of the 18th-century Canadian landscapes and gardens (Rousseau and Béthune, 1977). Similarly, between 1742 and 1743, M. Gaulthier, médecin du Roi, conseiller du Conseil supérieur de Québec et correspondant de l'Académie Royale des Sciences, while stationed in Canada, conducted botanical and meteorological surveys.

A plan survey of Artillery Park, a national historic site in Quebec City, occupied by the military for nearly 300 years, has shown that it contains a variety of woody and herbaceous plant material which has persisted over the years. As well as native medicinal plants, a number of other plants grown by French and later English military for culinary, medicinal and domestic purposes have survived. These include hopvine, used in brewing beer; coltsfoot, popular with the French for relief of pulmonary disorders such as coughs, asthma and pneumonia; tansy, used in domestic medicine; and solomon's seal, a native plant, employed as a poultice as well as an ornament. These descendants of historic plant species are just as much artifacts of domestic life as the pieces of pottery, glass and metal unearthed in an excavation. Identifying, protecting and interpreting them permits reconstruction of historic landscapes using the actual descendants of the original flora.

Vegetative evidence on a site can provide considerable information. For example, large clumps of common lilac (*Syringa vulgaris*) are a sure indication of former habitation. Old damask rose (*Rosa gallica*) is another and yarrow (*Achillea L.*), an herbaceous escapee, native to Europe, is yet another commonly grown plant used medicinally. Native material such as cardinal flower (*Lobellia cardinalis*) was grown for its medicinal value. Among the exotic plants introduced to an area that persist long after a site has been abandoned, are peonies, tulips and narcissus. A classic example of vegetative evidence providing information occurs at Macdonnel House, Pointe Fortune, Ontario, where the walk follows exactly the depression of the old walk in the ground. For years irises, tulips, jonquils, hyacinths and other plants came up in the spring on either side of the walk. These plants indicated the location of the flower borders and the walk they outlined.

As well as herbaceous material providing clues, other indicators can be spotted at some distance. Such evergreens as the Norway spruce, native to central and northern Europe, spire above most native material. As well as delineating driveways, Norway spruce was used extensively by exponents of the "natural style." Black locust and lombardy poplar were both used extensively during the 18th and 19th centuries to delineate boundaries and are likewise often still to be found. Lilac (*Syringa vulgaris*) and fruit trees, particularly when they are in flower, stand out from native vegetation.

The placement of plants is another clear signal of human occupancy. Native sugar maples do not grow naturally in straight lines evenly spaced. When trees of common size are seen, or a clump which would not grow naturally together is found, it is quite likely that there was a planting program and some intention to landscape.

There were some traditional customs regarding where particular plants should be placed. Lilac became almost synonymous with the outhouse and lily-of-the-valley and periwinkle with the north wall of the house. In field work, a mass of periwinkle suggests the location of foundations of a structure. It was customary in some religious groups to plant two evergreens or two fruit trees when a couple were married. Planting a tree with the birth of each child was also very common in certain regions. These were lined up across the front property line. Certain plants were frequently used because of their ability to withstand harsh treatment.

6.0 EARTH WORK AND SITE GRADING

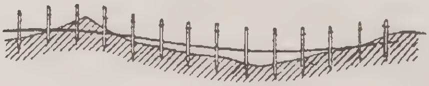
Site contours or grades are an essential characteristic of a historic property. The location of a building was often dictated by terrain, as were sanitary sites and agricultural activities. Military sites provide some of the most elaborate examples of earthwork and grading schemes.

Excellent descriptions of grading and earth moving are contained in the Rideau Canal construction documents, which outline the specifications for work to be done and give prices.

One of the agreements, which is in the National Archives of Canada, is that made with William Hartwell. It covers the clearing and excavation of the necessary channels between Rideau and Mud Lakes and between Indian and Clear Lakes. The "unit prices" are 20 pounds per acre for chopping, 4 shillings per cubic yard for rock excavation and 1 shilling per cubic yard for earth excavation. Excavation of soil was by hand with picks and shovels; the earth was transported to suitable dumping areas by wheelbarrows. The only haulage available was that provided by oxen at a few locations.

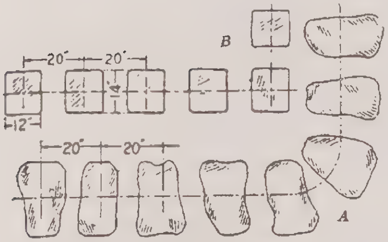
Planting of curves, and free views. Entrance at right angle to highway

Walk crossing a lawn in slight depression for concealment

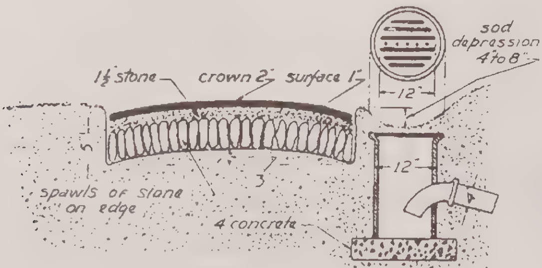


Transition of grades. Method of sighting by stakes and twine

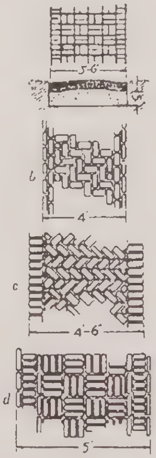
Directions for laying out walks and paths such as these illustrated in Bailey's Horticulture, *1900, urged practicality but stressed the importance of dry surfaces for major traffic areas.*



A, Stepping-stones in the grass—the simplest dry path in the natural style. B, The same, conventionalized for the formal style.

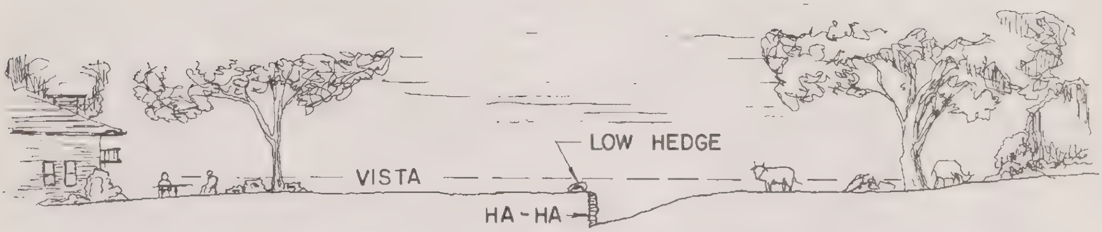


Gravel or macadam walk.



Forms of simple brick walks. *a*, Basketry pattern; *b*, straight herringbone; *c*, herringbone, corner cutting required but effectiveness of pattern increased; *d*, basket, with Roman (or extra-size) brick.

Detailed directions for types of paving, methods of laying brick and designs for a drain next to the walk. Horticulture, *1900.*



A PASTORAL EFFECT WITHOUT DANGER OF INVASION

In the days when cows and sheep were, from choice or of necessity, a part of the landscape, they were prevented from reaching the lawn by an arrangement known as the "ha-ha," the construction of which is pictured here.

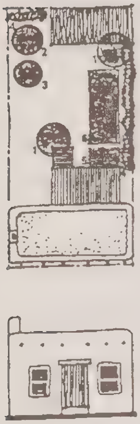
There is no mention in any of the records of the work of even so primitive an aid to manpower as a horse-drawn scraper. Rock, which had to be removed from cuttings or as it was required for stone masonry, was excavated by drilling holes which were then filled with gunpowder and blasted.

On a domestic scale, the "ha-ha" is an example of an earthwork. The "ha-ha," consisting of a ditch lined on one side by a fence or wall, was used on large estates to keep grazing animals from encroaching on gardens and other landscape elements close to the dwelling. While the "ha-ha" was used in Canada, it was particularly in vogue in England during the 18th century when Humphrey Repton advocated natural effects in landscape design. Because an exposed fence or wall would reveal human interference in the landscape, the barrier was sunk in a ditch, thus maintaining an uninterrupted view of surrounding nature from the house.

Changes to historic site contours and land forms are a means of discovering former patterns and ground arrangement. For example, crop marks or archaeological marks are often visible in open fields. They can be most easily recognized in monocultures, particularly cereal crops, but are evident in meadows and grasslands. Normally crop marks are caused by the subsoil, principally its depth, nutrient content and moisture. Darker lines or spots occurring in a field suggest rich fill where deep root penetration causes plants to ripen slowly; lighter areas indicate poor growing conditions and less luxuriant plants that mature earlier than the surrounding vegetation. Archaeological markings in pasture or meadowlands are much less evident than in cropland. They can best be seen early in the season when there is higher available nitrogen in the soil or later in the year when dried out areas or parch marks appear. Water level is an important factor in crop mark formation, as is the structure of the subsoil. Generally, the more porous the soil, the better the chance of seeing crop marks. Heavy clay soil does not produce good crop marks, nor does sandy soil. Ground that has been disturbed and subsoil overlaying the topsoil can be recognized by the distinct changes in plant materials growing in clumps next to each other.

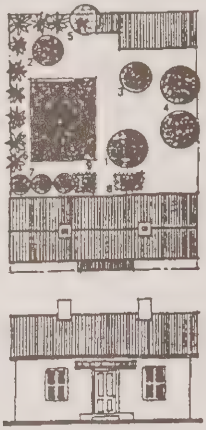
Before carrying out landscape grading of a historic site, a detailed site plan with all the associated information is needed. A site plan that accurately locates buildings, trees, shrubs and ground contours as well as roads, paths and enclosures will often reveal significant patterns less readily seen on the ground. Aerial photographs are an important aid to landscape interpretation. Infrared aerial photography has become a valuable technique that can be used to advantage. Colour photographs and oblique air photographs taken in low light provide evidence of earlier use patterns. Even oblique views from a second storey or a tall tree can reveal pertinent information. Familiarity with the features on the ground is obviously an important factor in understanding and interpreting air photographs. Usually the best time of year for taking aerial views is early spring. Crop marks or archaeological marks can best be seen early in the growing season while the grass is new and green and the leaves of deciduous trees are not fully out. Late summer after a dry spell is also a good time for aerial photographs because dried out areas or parch marks will appear.

Architectural Styles and Ornamental Plant Use



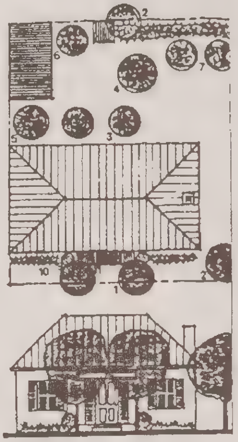
Sonoran

Some shade trees in back garden along with vegetables and herbs.



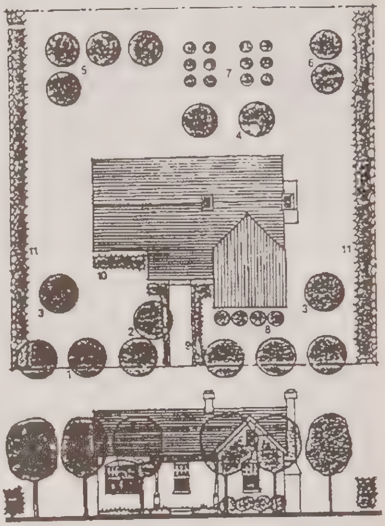
Early Transitional

Shade trees, some fruit and nut trees, vegetables and herbs in back garden.



Late Transitional

Front and side setbacks along with the availability of more varieties of plants results in some ornamental landscaping.



Victorian

Full setbacks and numerous varieties of plant materials results in much ornamental planting.

Sonoran

1. **Parkinsonia aculeata** Mexican palo verde (volunteer)
2. **Ficus carica** edible fig
3. **Punica Granatum** pomegranate
4. **Opuntia Ficus-indica** Indian fig (used as cactus hedge)
5. **Aloe vera** aloe and herbs
6. Vegetables

Early Transitional

1. **Schinus Molle** California pepper
2. **Prunus Armeniaca** apricot
3. **Citrus aurantifolia** edible lime
4. **Phoenix canariensis** Canary Island date
5. **Cercidium floridum** blue palo verde
6. **Agave americana** century plant (used as hedge)
7. **Sambucus mexicana** Mexican elderberry
8. **Aloe vera** aloe and herbs
9. Vegetables

Late Transitional

1. **Fraxinus velutina** Arizona ash
2. **Prosopis juliflora** mesquite
3. **Melia Azedarach** chinaberry
4. **Olea europaea** olive
5. **Citrus sinensis** edible orange
6. **Ficus carica** edible Fig
7. Citrus grove (grapefruit and orange)
8. **Nerium Oleander** common oleander
9. **Rosa Banksiae** Banksia rose
10. **Rosmarinus officinalis** rosemary
11. Perennials

Victorian

1. **Fraxinus velutina** Arizona ash
2. **Morus alba** fruitless mulberry
3. **Washingtonia filifera** California fan palm
4. **Phoenix canariensis** Canary Island date
5. Citrus grove (grapefruit and orange)
6. **Prunus Persica** peach
7. **Rosa sp.** (ornamental rose varieties)
8. **Pittosporum Tobira** Japanese pittosporum
9. Annuals
10. Perennials
11. **Ligustrum japonicum** wax-leaf privet

From Landscape Architecture, *May 1979.*

7.0 BIBLIOGRAPHY

American Association for State and Local History. 1974. "Historic Landscapes and Gardens: Procedures for Restoration." Technical Leaflet 80. *History News,* Vol. 29, No. 22 (November). Nashville.

Anthony, John. 1972. *Discovering Period Gardens.* Shire Publications.
Surveys the development of gardens in Great Britain through history.

Association for Preservation Technology, Bulletin of the. 1977. Vol. 9, No. 3. Ottawa.
The issue is devoted to landscape and garden research and to the technical problems encountered in their preservation and restoration.

______. 1986. Vol. 18, Nos. 1 & 2.
Special Environment Canada - Parks. Double issue.

Binney, Marcus, and Ann Hill. 1979. *Elysian Gardens: A Strategy for Survival.* Save Britain's Heritage, London. Numerous illustrations show how styles of gardens have changed in the course of the last century. It focuses on need for protection and means to facilitate garden's preservation.

Brooklyn Botanic Garden. 1968. "America's Garden Heritage, Explorers, Plantsmen and Gardens of Yesterday: The Origins of American Horticulture," *Plant & Garden,* Vol. 23, No. 3.

Canada Mortgage and Housing Corporation. 1983. *Site Improvement of Older Housing.* Ottawa.

Canadian Horticulturalist, The. L. Woolverton, ed. Published by the Fruit Growers Association of Ontario, M.A. Copp Clark Company Limited, Grimsby, ON.

______.1880. D.W. Beadle, ed. "Arrangements of Lawns," Vol. 3, p. 93; "Screens," p. 191.

______. 1881. D.W. Beadle, ed., Vol. 4.

______. 1889. "A Small Green House," Vol. 7, No. 4 (April), p. 4.

______. 1887. "Hints on Formation of Lawns." Vol. 10, pp. 108-10.

Council of Planning Librarians. 1974. John A. Jakle, comp. *Past Landscapes: A Bibliography For Historic Preservationists from the Literature of Historical Geography.* Monticello, IL.

De Forest, Louis Effingham, ed. 1932. *Louisbourg Journal 1745.* The Society of Colonial Wars in New York, New York.

Downing, Andrew Jackson. *Cottage Residences, or a Series of Designs for Rural Cottages and Cottage Villas and Their Gardens and Grounds.* Reprinted 1967 - American Life Foundation, Watkins Glen.
Illustrates early American gardening practices.

Everett, T.H., ed. 1950. *New Illustrated Encyclopedia of Gardening.* Greystone Press, New York.

Favretti, Rudy J., and Gordon P. DeWolf. 1972. *Colonial Gardens.* Barre Publisher.
Contains useful plant lists and practical information for the restoration of early American gardens.

Favretti, Rudy J., and Joy Favretti. 1977. *For Every House a Garden.* Pequiot Press, Chester, CT.

Fortier, John. 1972. "The Fortress of Louisbourg and its Cartographic Evidence," *Bulletin of the Association for Preservation Technology,* Vol. 4, Nos. 1-2, pp. 3-107. Ottawa.
Through documentary illustrations and cartographic evidence, the author shows images of the Fortress of Louisbourg, "the seat of the colony of Ile Royale and watchpost of the St. Lawrence." Comprising one of the first "town plans" in North America, the maps of the fortress show an abundance of detail and are very well drawn, though not always completely accurate. Nevertheless, in terms of landscape, they provide the reader with the general layout of gardens within the town and an overview of the town within the surrounding landscape.

Gauthier, Jean-François. 1744. "Observations botanico-météorologiques faites à Québec par M. Gautier (sic) pendant l'année 1743," *Histoire de l'Académie royale des sciences.*

Gentilecore, R. Louis, and C. Grant Head. 1983. *Ontario's History in Maps.* University of Toronto Press, pp. 89-90. Toronto.

Government of Canada. n.d. Master Specifications, Division 2, Site Work.
Under this heading the following sections and subsections are listed: Clearing, Demolition, Earthwork, Pile Foundation, Site Drainage, Paving and Surfacing Landscaping.

Harvey, Mary MacKay. 1975. "Gardens of Shelburne, Nova Scotia 1785-1820," *Bulletin of the Association for Preservation Technology,* Vol. 8, No. 2, pp. 32-72. Ottawa.
Many of the problems involved with restoring or reconstructing historic gardens are dealt with in this complete and systematic study of the gardens of Nova Scotia 1785-1820. The approach and procedure utilized in this study are outlined to serve as a guide for other historical organizations faced with similar surveys. The aims of the study are presented, followed by a general discussion of the history of Shelburne and the history of gardens, the types of primary and secondary sources used to assemble a plant list, and the necessity for a consultation with a botanist prior to the planting of a garden. The article also presents an inclusive list of plants and seeds available in Shelburne, 1785-1820.

Hunt, John Dixon, ed. 1981. *Journal of Garden History.* Vol. 1, No. 2 (April-June). Taylor & Francis Ltd., London.

Hunt, Peter, ed. 1964. *The Shell Gardens Book.* Phoenix House in association with George Rainbird, London.

Illustrated Annual Register of Rural Affairs, The. 1868. *Stone and Gravel Roads.* No. 14. Albany, NY.

Landscape Planning. Vol. 6. Elsevier Scientific Publishing Company, Amsterdam.

Langton, W.A., ed. 1926. *Early Days in Upper Canada - Letters of John Langton.* The Macmillan Company of Canada, Ltd., Toronto.

Leighton, Ann. *Early American Gardens for Meate and Medicine.* Reprinted 1970. Houghton Mifflin Co., Boston.
17th-century New England gardens: what was found growing, what was planted and what was followed as fashion.

Lynch, Kevin. 1962. *Site Planning.* Massachusetts Institute of Technology. The MIT Press, Cambridge, MA.
Discusses site planning and the various aspects of site work as it applies to organization and understanding of building arrangement.

Martin, George. 1887. *Fences, Gates, and Bridges: A Practical Manual.* Reprinted 1974. The Stephen Green Press, Brattleboro, VT.
An informative book on traditional types of wooden and metal enclosures.

McKee, Harley J., ed. 1971. *Recording Historic Buildings.* U.S. Government Printing Office, Washington, DC.
Pages 120-24 outline a technique of making landscape site surveys and measured drawings.

Michaud, Claude. 1983. "Analysis of Architectural Landscape," *Bulletin of the Association for Preservation Technology,* Vol. 15, No. 4. Ottawa.
This is part of a macro-inventory guide carried out by Quebec. It is the study of places and the hypothesis that there are two main aspects of how popular architecture and land use contribute to creating specific architecture.

Minhinnick, Jeanne. 1970. *At Home In Upper Canada.* Clarke, Irwin & Co., Toronto.
This discussion of domestic life in Upper Canada, the present province of Ontario, includes a description of early gardens and a list of historic plants.

Ottawa, City of. 1984. *Sandy Hill's Heritage Districts: Streetscape Guidelines.* Commonwealth Historic Resource Management Limited, Ottawa.
The Department of Community Development, City of Ottawa, commissioned the study "to provide guidelines on the enhancement of streetscapes and provide direction on the development of important landscape elements in the Sandy Hill Heritage Districts."

Preservation League of New York State. n.d. *Historic Landscape Preservation and Restoration: An Annotated Bibliography for New York State.* Resources Series, No. 3. Albany.

Schmidt, Carl F. 1963. *Fences, Gates and Garden Houses.* Carl F. Schmidt, Rochester.
Measured drawings and photographs of early 19th-century examples of these important garden elements.

Scott, Frank J. n.d. *The Art of Beautifying Suburban Home Grounds of Small Extent.* Reprinted 1977. American Life Foundation, Watkins Glen.
Refines theories of Downing and includes numerous examples of their practical application to domestic landscapes. Reprint title: *Victorian Gardens.*

Sharpe, Grant W. 1976. *Interpreting the Environment.* John Wiley and Sons Ltd., New York.

Stewart, John and Susan Buggey. 1975. "The Case for Commemoration of Historic Landscapes and Gardens," *Bulletin of the Association for Preservation Technology,* Vol. 7, No. 2, pp. 99-123. Ottawa.
A brief history of landscaping in the 18th and 19th centuries in Canada introduces this article which defines types of historic landscaping that should be preserved. These types are defined by employing categories established by David Streatfield in his article, "Standards for Historic Garden Preservation and Restoration," from *Landscape Architecture,* Vol. 59, No. 3 (April 1969). Descriptions of surviving historic gardens in Canada exemplify each of the six categories.

Sykes, Meredith, and John J. Stewart. 1972. "Historic Landscape Restoration in the United States and Canada: An Annotated Source Outline." *Bulletin of the Association for Preservation Technology*, Vol. 4, Nos. 3-4, pp. 114-58. Ottawa.
A suggested outline for classifying material on historic landscape preservation under five headings.

Tishler, William H., and Randy Joy Garder, eds. 1976. *Historic Preservation and Cultural Landscape: An Emerging Land Use Planning Concern.* School of Natural Resources. University of Wisconsin, Madison.
Essays by graduate students in the Department of Landscape Architecture and Environmental Awareness Centre on conserving historic values in rural and urban environments.

Untermann, Richard K. 1973. *Grade Easy.* Landscape Architecture Foundation Inc., McLean, VA.

Von Baeyer, Edwinna. 1984. *Rhetoric and Roses: A History of Canadian Gardening: 1900-1930.* Fitzhenry & Whiteside, Toronto.

Weddle, A.E., ed. 1979. *Landscape Techniques.* Van Nostrand Reinhold Company Inc., New York.

Wylie, E.A. ed. 1975. "Some Notes on Architecture, Interiors, and Gardens in Quebec, 1831," *Bulletin of the Association for Preservation Technology,* Vol. 7, No. 2, pp. 2-8. Ottawa.
Excerpts from "Recollections of Canada 1831" by L.A. Aylmer in the *Rapport de L'Archiviste de la Province de Québec*, 1934-35, pp. 279-318, provide an insight into the pattern of life and the surroundings of an early Governor of Lower Canada by describing the interiors, exteriors and gardens of his three residences in Canada.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

3
PERIOD CONCRETE WORK

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: A. POWTER

CONTENTS

1.0 INTRODUCTION

The earliest date for the manufacture of cement in North America was 1818 when it was used in constructing the Erie Canal. In Canada, cement was first manufactured at Hull, Quebec in 1827. These natural cements or hydraulic limes were used throughout the century in large quantities for foundations, mortar, renders and tank linings. They were also used in marine work where they were prized for their waterproofing and setting characteristics.

The North American natural cements were adequate for these applications. They also had the advantage of being considerably cheaper than the Portland cement which could be imported from Britain and Europe from 1865 on. Imports of Portland cement increased steadily until domestic manufacture began, in the 1870s in the U.S. and in 1889 in Canada. For the first ten or fifteen years the domestic product was considered inferior to the import, but it was eventually upgraded and could be relied on to give satisfactory, uniform results. Between 1896 and 1910 the domestic Portland cement industry expanded and multiplied at the expense of the domestic and foreign natural cement industry. This is graphically illustrated by Portland cement exhibits at the Chicago World's Fair in 1893 and the Louisiana Purchase Exposition of 1904. Although the Chicago Fair included several large displays by foreign makers and none by Americans, by 1904 this situation was reversed.

The twenty-year period between 1890 and 1910 was a time of rapid change and growth in the North American cement and concrete industry. Prior to 1890 most concrete construction consisted of mass work containing relatively primitive reinforcement, if any at all. By 1910 reinforced concrete was generally accepted as a construction material with practically unlimited possibilities. This publication will provide a sampling of available information on construction practices from this time period. Information from earlier and later periods, particularly regarding military work, are included where relevant.

The quotations have been selected to present a broad view of the considerations and techniques involved in building with concrete. Although some attempt has been made to draw attention to inappropriate construction methods, the user is left to judge the long-term effect of the particular techniques. The emphasis is on site practices; consequently, questions of design have been left out.

Documentation of concrete construction technology by people actually performing the work is scarce. Also, this is a field which has attracted little attention from researchers. Consequently the most extensively quoted sources are texts on concrete construction technology. These texts have a disadvantage because they describe recommended practice rather than actual practice. Fortunately the authors occasionally point out common practices which should be avoided or should be checked during site inspections.

Trade and professional journals are also quoted, among them the *Canadian Architect and Builder, American Carpenter and Builder* and the *Professional Papers of the Royal Engineers.* The illustrations are taken from the references and from the photo collection of the National Archives of Canada.

2.0 DEFINITIONS

2.1 ARMOURED CONCRETE: REINFORCED CONCRETE*

Beton: A concrete made from a hydraulic lime which requires slaking before mixing with other ingredients (Dobson, p. 43). A widely used term for concrete used in France and the USA in the late 19th century.

Concrete: An artificial conglomerate or pudding stone in which the pebbles which make up the greater part of its bulk are cemented together by lime mortar. A weak artificial stone with little transverse strength even when hard (Dobson, p. 39).

Crystallization: Setting of cement due to reaction with water.

Gauging: Stirring or mixing.

Hydration: A chemical change due to reaction with water.

Joggling: See puddling.

Puddling: Action of compressing wet concrete in the forms by sliding a rod up and down in the mass.

Ramming: Action of pounding or beating concrete to compress the mass, force out the water, force the aggregates together and reduce voids.

Rubble concrete: Concrete made by throwing large stone aggregate into the forms as the concrete is placed.

Setting: Solidification or loss of plasticity. To be distinguished from hardening.

Slicing: See puddling.

Spading: Technique used to push large aggregate back away from contact with the forms.

Tamping: See ramming.

Tensile strength: Measure of the adhesiveness or holding power of concrete.

Voids: The air spaces between the particles of aggregate.

** Radford's, 1909, unless otherwise noted.*

3.0 SITE ADMINISTRATION

3.1 ESTIMATING QUANTITIES AND COSTS

The references in this section are not exclusively concerned with the techniques of estimating. Instead, they were chosen to give an idea of the relative costs of materials and different types of work.

Quotations which state only costs have been purposely omitted. The references can be consulted directly for that information.

> With respect to the economy of using concrete instead of brick or stone... it appears, that concrete in foundations may generally be formed at one-third and in arches and walls at less than half the cost of brickwork (Alexander, pp. 33-42).

The strength and efficiency of concrete construction was also compared to that of brick work.

Materials	**Weight** per ft^3 (lbs)	**Tenacity** per sq. inch (lbs)
Brick in mortar	100	50
Concrete in Scott's cement	140	120
Rammed backing	100	...

> The foregoing table shows that the concrete in question is far superior to brickwork as material for the construction of retaining walls, being 40 per cent, heavier and more than twice as strong.
>
> The economy of using concrete instead of brickwork is very great. In the case of Newhaven Fort, the contract price of brickwork, per rod, is £8 5s. That of concrete, in Scott's cement, is, per yard, 5s. 10d. or £3 6s. per rod. When the additions for labour to faces, cuttings, splays, pointing, etc., are made to the brickwork, its cost is raised to nearly three times as much as the concrete (Ardaugh, pp. 161-68).

William Ward kept precise records of costs during the construction of his house in New York state in the 1870s. He refers to his system as "béton" construction and gives costs of 60 cents per square foot for beams, floors and roofs and 24 cents per cubic foot for heavy wall work. Both figures include formwork and reinforcing. He attributes the low costs to cheap material – since raw materials were plentiful – and cheap labour, since the skills could be learned in half a day.

In the construction of the defensive works at Cork Harbour in Ireland in the 1870s the costs outlined in the following table were encountered. These costs were based on Portland cement at 63s. per ton, sand at 4s. 5d. per cubic yard, limestone at 3s. 6d. per ton and allowances for formwork, centering, boulders on hearting of large stones and machinery.

Henry Faija in 1884 described the economy of using hydraulic cement in mortar over lime. He argued that a six-inch slab of cement concrete, with a proportion of cement to aggregate of not more than one to seven or eight, was equivalent in strength to a 12-inch slab of ordinary lime concrete, with a proportion of lime to aggregate of one to four. He concludes his account, however, with a caution against such a high sand to cement ratio in terms of workability and suggests loam as a possible admixture.

Kidder in 1896 gave basic data for estimating the materials required for given quantities of cement:

> **147. Data for Estimating.** There seem to be few records of careful measurements of the amount of materials required to make a cubic yard of concrete, but the following data is believed to be reasonably accurate:

NATURE OF WORK	PER CUBIC YARD		
	Military Labour		Estimated Cost by Civil Labour
	Mixed by Steam Power	Mixed by Hand	
Dock Work or Sea Walls between High and Low Water: Concrete of shingle, with half of mass boulders collected within 100 yards of site; railway bar iron and 3-in. plank sheeting….	-	9s. 4d.	12s. 10d.
Moncrieff Pit Batteries: Concrete of stone broken by machinery…, sand supplied by contractor, framed sheeting, straight and circular	11s. 0d.	12s. 1d.	15s. 2d.
Casemated Batteries: Concrete in walls, with half hearting in big lumps; stone quarried near site; concrete trucked by tramway 150 yards; sand supplied by contractor….	8s. 4d.	9s. 8d.	12s. 9d.
Casemated Batteries: Arches all of concrete without hearting; the materials as in last case….	11s. 4d.	12s. 9d.	16s. 4d.
Dwelling Houses: Concrete in hollow walls, surfaces worked smooth both sides, panels and framed sheeting; lime, stone, and sand at contract prices…	15s. 10d.	16s. 3d.	19s. 9d.

(Maquay, 1873, pp. 149-50).

Used in the proportion of 1 part cement, 3 of sand and 5 of broken stone, in sizes not exceeding 2 x 1-1/2 x 3 inches, one barrel of cement will make from 22 to 26 cubic feet of concrete, the average being about 23 cubic feet.

In putting in the foundations of the Cathedral of St. John the Divine, New York, it required 17,000 barrels of Portland cement to make 11,000 yards or about one and one-half barrels to the yard. The proportions were 1, 2 and 3.

Concrete made of 1 part of cement, 2-1/2 of sand, 3 of gravel and 5 of broken stone gave 1.18 yards of concrete to a barrel of cement.

The ordinary cement barrel contains about 3-1/2 cubic feet.

At $2 a day for labor, the cost of mixing and depositing concrete should not exceed $1 a cubic yard. The cost per yard of Portland cement concrete will generally vary from $6 to $8, according to the cost of the cement, labor and aggregates (Kidder, p. 122).

Taylor and Thompson, in 1907, estimated total costs per cubic yard at about $4 to $7 for large masses or heavy walls, $7 to $14 for sewers or arches requiring centering and $10 to $20 for thin walls.

They also described in detail several other cost considerations for concrete work, such as freight costs for Portland cement and screening and freight costs for sand and gravel. They pointed out the variables in labour costs, such as the experience of the crew, the complexity of the formwork and the effect of the water to cement ratio on the levelling and ramming operation.

The Ingalls Building, designed by the Ferro-Concrete Construction Co. and erected in Cincinnati, Ohio in 1903, was the first notable example of a North American concrete-built office building. Its costs were used as a reference by Taylor and Thompson in the following excerpt.

> The cost of the reinforced concrete for an office building built of this material in 1904, based on actual construction records, with cement at $2.00 per barrel delivered on the work, was about 20 percent less than the estimated cost of the steel and tile of ordinary fireproof construction. As the concrete construction constituted about one-fifth of the total cost of the building, the net saving is reduced to about 4 percent, a very considerable sum, however, when figured on a fifteen-story office building. There is also an additional saving in other materials due to the reduction in height of the building because of the thin concrete floors and to the fewer coats of plaster, with omission of furring, on walls and ceilings.
>
> Although the expense of construction forms presents an obstacle to the general use of reinforced concrete for factory buildings, in cases where contracting firms own the necessary appliances, this material may eventually prove cheaper than 'slow-burning' mill construction with brick walls and timber beams and columns. With Portland cement at $1.85 per barrel, including freight, the costs for reinforced concrete in representative factory buildings ran from 8 percent to 10 percent higher than the estimate for brick walls, timber columns and girders and plank floors. As the concrete portion was only about one-half the total contract, the increased cost of the entire building was 4 percent to 5 percent. The concrete building has greater durability and is fireproof, thus affording lower insurance rates.
>
> For dwellings and other small buildings the forms alone may exceed that of the materials and labor on the concrete. In estimating the labor, allowance must be made for the time which is often necessarily lost in waiting for the cement to harden or the forms to be removed. For these reasons it may be more economical to work with a small gang, taking an entire day to lay the concrete to the height of one section of forms.
>
> For the cellar and foundation walls of frame or brick houses (see p. 461), concrete is frequently cheaper than rubble masonry (Taylor and Thompson, pp. 449-50.)

The American Steel and Wire Co., a manufacturer of concrete reinforcement, provided similar cost figures in 1900 to those quoted by Taylor and Thomson. They strongly recommended the use of skilled contractors to speed the process.

3.2 MATERIALS

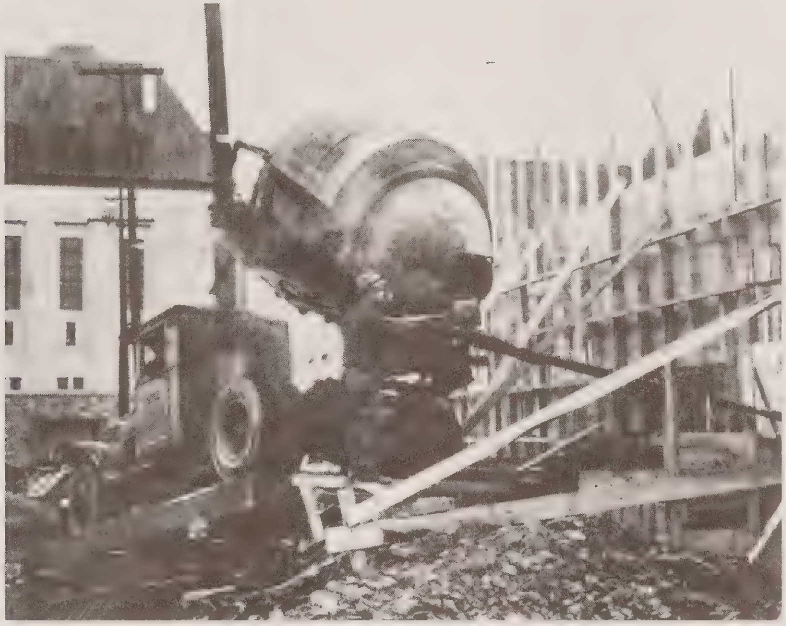
The principal materials used in concrete construction until the last decade of the 19th century were cement, aggregate, water and chemical additives. Metal reinforcement was used in significant quantities in North America only from about 1900. Selection of materials is a design function, usually carried out by the architect or engineer, leaving little to the discretion of the contractor. However, a discussion of the materials cannot be excluded when describing a particular construction technology. This section concentrates on the issues surrounding the materials used in concrete construction during the period.

3.2.1 Cement

Mid-19th-century specifications for cement regularly stipulated to the contractor the source of the material, fineness of grinding and weight per unit volume. Finely ground, dense cements were known to provide rapid setting and greater strength. By the 1880s specifications generally described particular tests the cement was required to pass; for example, tests for fineness, soundness and indentation. By the first decade of this century specifications had become extremely complex, containing relatively precise chemical, physical and performance descriptions of the material. Such precise specifications were possible because, by the turn of the century, cement had become relatively reliable and uniform in quality. However, repeated warnings of substandard materials and substitutions of brand marks did appear. It was commonly advised that for large projects the client should purchase and test the cement and then supply it to the contractor.

The following quotation contains a reference to cement used in the construction of the Rideau Canal, 1827-32. Although it is not in the period described, the information is useful.

> The cement was obtained from Philemon Wright of Hull and, as was suggested, it was mixed with clean white washed sand in the proportion of one third of sand to the quantity of cement preparatory to its use. Of its properties and values, Lt. Frome wrote 'The cement (Hull cement) was made from stone quarried on the opposite side of the Ottawa which,



Courtesy of the National Archives of Canada

> being burnt and ground very fine proved a better water-cement than some obtained from the States, and far superior to the Harwich cement which was nearly spoilt before it reached the Canal.' Financially, it was also more sensible to obtain the cement from Hull since the price per bushel of local cement was lower than that from England, and all the high costs of packaging and freight were avoided (Price, p. 37).

In 1865 Lt. Ardaugh specified the cement and method of measuring for the ditch revetments to be constructed at Newhaven Fort, another Royal Engineers project.

> The Scott's cement is to be finely ground, to contain not less than 10 per cent of soluble silica, to weigh at least 60 lbs. per striked bushel, [filled into a measure as lightly as possible] and to bear the following test, viz., when mixed with two measures of sharp washed sand to one measure of cement and moulded into the form shown in the annexed sketch, it is to form a sufficiently coherent mass in 24 hours, to allow of its removal from the mould; and when a block so made has been exposed to the air in a dry place for seven days (from the time of mixing), it is to support a longitudinal strain of not less than 65 lbs. (Ardaugh, p. 162).

Fifteen years previous Dobson had specified only that the lime be "beaten or ground to a powder" (Dobson, p. 45). The specifications for cement for the East Block, Departmental buildings, Ottawa were also less precise:

> The concrete to be formed of the best well burnt hydraulic lime (fresh burnt) mixed in the proportion of one part of lime to seven parts of gravel sand and broken stones. The lime is to be ground under the edge runners and left dry under cover in bags till required for use. The paving of the basement rooms and passages to be formed with the same material (Department of Public Works [DPW], 1859).

When the Fox and Barrett fireproof floor was specified in 1863, the concrete was described as follows:

> Such concrete to be made of the best Thorold cement and of the following ingredients, viz: Nepean and Potsdam finely broken stone. The proportions for concrete to be correctly ascertained and, the cement is to be brought fresh and kept dry in bags under cover till used (DPW).

Specifications for Portland cement indicated the substantially higher weight per bushel compared to the Scott's cement of 1865. The following reference from Major Maquay provides a summary of late 19th-century concerns:

> To recapitulate the essential points for attention in the use of Portland cement concrete: As regards the cement and the testing process, it should be heavy and ground very fine; 110 lbs. to the bushel is a good weight. Cement lighter than this will set fast, but will not attain as great a hardness as a cement heavier than the weight quoted. The greater the fineness of the ground article the more cementing properties it will develop; all coarse particles of cement are only so much sand in the powder, for this reason the excess of 20 per cent that will not pass a sieve of 2,500 meshes to the square inch should be rejected or deducted from the quantity received from a contractor. Should the cement contain too much chalk in its constitution, it will be detected during the operations of testing by the wet pat cracking and swelling; or if it contains more than a proper proportion of clay, it will show itself by the dry pat shrinkng and setting of a yellowish instead of a light grey colour. In either case it is desirable to reject the cement, though its tensile strength may come up to specification (Maquay, p. 149).

Other references can be found in Grant, 1859, quoted in the American Concrete Institute collection and Maquay.

When writing on the construction of the Trent Canal, H.F. Greenwood made the following comments regarding cement:

> The cement for the season was let by contract, to be delivered in cars at the railway siding nearest the work, where it was handed over to the contractor. One of our Canadian firms, the manufacturers of the

A Complete Concrete Hand-Mixing Plant for Small Batch Work (Radford's)

> Star brand, secured the contract, but they were not able to keep the works supplied and also satisfy the demand from outside customers. The consequence was that after a time they supplied us with the Condor and Josson brands of Belgian Cement. All the above mentioned brands gave good satisfaction, but the Star brand was found to be more finely ground than the other cements (Greenwood, p. 87).

Greenwood also indicated that quality control testing of the cement for this project was being done by a government laboratory.

> The specifications state that the contractors shall supply at their own cost, all plant, labor, moulds and materials necessary for the satisfactory execution and completion of the works, with the exception of the cement, which is supplied by the government (Greenwood, p. 87).

Portland cement was assumed to be reliable although brands varied. It was possible to write a sufficiently precise specification to ensure a good quality material. Like Baker, Ransome and Butler, Kidder simply named the material in his articles.

The specifications were fully detailed in the appendix. This was also the practice in Taylor and Thompson's text of 1907:

> It is a wise rule to require Portland cement for nearly all classes of concrete. Portland cement is more uniform and therefore more reliable, while its strength is so much higher than natural cement that by mixing it with larger proportions of sand and stone, properly graded, it will usually yield better results at less cost than natural cement.

> The cement shall be first-class Portland cement of reputable brand which shall conform in all respects to the cement specifications herewith annexed (Taylor and Thompson, p. 12).

C. Hill published a book in 1909 on inspecting concrete work. In it he gave some useful comparative data on cements.

> The commercial unit of measurement of concrete is the barrel; the unit of shipment is the bag. A barrel of Portland cement contains 380 lbs. of cement and the barrel itself weighs 20 lbs.; there are four bags (cloth or paper sacks) of cement to the barrel. The amount of cement in a barrel varies, due to differences in weight of cement and to differences in compacting the cement into the barrel. A light burned Portland cement weighs 100 lbs. per struck bushel; a heavy burned Portland cement weighs 118 to 125 lbs. per struck bushel. The number of cubic feet of packed Portland cement in a barrel ranges from 3 to 3-$^1/_2$. Natural cements are lighter than Portland cements. A barrel of Louisville, Akron, Utica or other western natural cement contains 265 lbs. of cement and weighs 15 lbs. itself; a barrel of Rosendale or other eastern cement contains 300 lbs. and the barrel itself weighs 20 lbs. There are 3-$^1/_2$ cu. ft. in a barrel of Louisville cement. Usually there are three bags to a barrel of natural cement (Hill, pp. 1-2).

The American Steel and Wire Company included a detailed classification of cements in their catalogue of 1908. This text is reproduced in the appendix.

Radford's Cyclopedia, 1909, included specifications for natural and Portland cements. These specifications indicated the level of complexity cement specifications had reached by 1909. Detailed requirements were given on specific gravity, fineness, time of setting, tensile strength, constancy of volume and maximum levels of sulphuric acid and magnesia.

3.2.2 Aggregate

Although the type of aggregate was believed to affect the final strength of concrete, it was considered by many to be essentially an inert filler. The general view that "dense concrete was strong concrete" was extended to aggregate; consequently hard dense aggregates were recommended. At the turn of the century most discussion about aggregates revolved about the following points:

- Where should a fracture occur – through the aggregate or at the cement to aggregate interface?
- Should aggregates be absorbent or hard? Hard aggregates were stronger, but absorbent aggregates achieved a stronger bond with the cement paste.
- Should aggregate be broken stone or gravel (rounded)?

Two points were clearly established: sand should be sharp, without excess fins and aggregate should be clean.

The following references describe several aspects of aggregate selection in the period. Note that there are no references to the cement-aggregate reactions.

William Ward's experiments of the 1870s indicated that finely crushed and screened stone made stronger concrete than coarse aggregate. Not only was less cement required but the resulting cement to aggregate bond was stronger. Ward's investigations convinced him to use sharp fine aggregate rather than a graded aggregate:

Even so, graded aggregate had been specified for the East Block, Departmental Buildings, Ottawa, in 1863:

> The coarse gravel or broken stones to be passed through a screen of one inch gauge and the finer gravel through a screen of half an inch gauge and no stones to be of a larger size.
>
> The gravel carefully prepared, free from pebbles and deleterious matter of any kind and mixed with a portion of clean sharp sand, as will be directed (DPW, p. 4).

Major Maquay, writing in 1874, suggested a variety of suitable materials for aggregate, including broken stone, hard bricks, chippings from stoneyards, gravel, ballast and burnt clay. An aggregate's important qualities were a moderately absorbent and rough surface to provide good adhesion; sharp, angular edges; and cleanliness.

Baker, in 1890, advised that aggregate be graded and, like Maquay advised, porous. He also linked the strength of concrete to the efficient filling of voids. He described several techniques for determining the proportion of voids in the aggregate and recommended that the proportion of matrix should slightly exceed this figure. The sizes of the individual pieces of aggregate were to be adjusted so that the smaller fit into the interstices of the layer. This he felt would allow the cementing material "to act to the best advantage" (Baker, p. 102).

Baker also argued that the strength of the concrete was more dependent on the cement to aggregate bond than on the strength of the aggregate itself.

Ransome, writing in 1894, reiterated the need for clean, rough, sharp aggregate, graded to provide the smallest possible proportion of voids. He also argued, however, that the aggregate itself be hard and tough and said that a good aggregate with a poor cement could sometimes give better results than a poor aggregate with good cement.

He provided a number of more specific observations, such as the avoidance of feldspar and limestone in fireproof work, the avoidance of overly fine crushing of granite, the use of a crusher (even when gravel is obtained) to break the larger pieces and the permissibility of larger aggregate in massive work.

Ransome had no objections to the presence of clay impurities in the gravel. Other writers of the period, however, such as Butler in 1895, advised that the aggregate be entirely clean, perhaps fearful that dirt or loam would be mistaken for clay. Opinion on the harmful effects of loam in concrete was universal. Greenwood also went to some trouble to obtain clay-free gravel for the Trent Canal work in 1897.

Kidder was content to recommend granite as the best aggregate – despite its brittleness – because of its hardness. He also stressed that aggregate be clean and angular. Surprisingly, Kidder also found that broken bricks and pottery formed acceptable aggregate.

Hill, in 1909, gave a lengthy list of acceptable aggregates, but recommended natural gravel. He clearly put a lot of importance on a good cement to aggregate bond. He also described other sources of aggregate, including the use of slag and cinders for fireproof work.

Hill advised that specifications should stipulate the type of sand or gravel, mineral composition, shape and size of grains, allowable loam content and allowable percentage of voids (Hill, p. 9).

Radford's, in 1909, repeated the emphasis on coarseness, cleanliness and sharpness. He lists the following materials as suitable for aggregate, in order of value:

1.	Trap	6.	Slag
2.	Granite	7.	Sandstone
3.	Gravel	8.	Slate
4.	Marble	9.	Shale
5.	Limestone	10.	Cinders.

(*Radford's*, Vol. 6, p. 77).

3.2.3 Admixtures

Early references indicate three main applications for admixtures: to protect against frost, to improve waterproofing and to achieve a more rapid set.

At the turn of the century common salt in concentrations of about ten percent was used to protect freshly placed concrete from the effects of frost. An earlier method suggested adding quicklime to the mix, as the heat generated by slaking prevented freezing. Glycerine, alcohol and sugar were also used.

Many waterproofing admixtures were available on the market in the first decade of this century. Many of these were patented products of the "snake-oil" variety; however, an addition of two percent hydrated lime was commonly recommended and calcium chloride was occasionally added as an accelerator.

Although several early references state that sea water was as acceptable as fresh water for mixing, the earliest reference to the deliberate addition of salt or brine was found in F. Kidder's *Building Construction and Superintendence*, 1896.

> Builders sometimes advocate the addition of lime to Rosendale cement mortar in cold weather to warm it. The heating effect of the lime, however, would not be appreciable, as heat is generated in lime only when it slakes. If cement of the Rosendale type must be used in freezing weather, the only safe way of using it is by the addition of salt, otherwise the mortar will be completely ruined by freezing (Kidder, p. 118).

It was possibly the practice in some parts of Canada to add quicklime to cement to protect against the effects of frost. Its use was documented during the construction of the Halifax Cathedral in 1908.

> With the consent of the contractors Canadian cement was used instead. Because it was the practice in Halifax (and had been for generations) to use mortar in which lime was mixed with the cement 'a small quantity of lime' was mixed in the mortar, a change which Goodhue described as 'defiance of our specifications.' Horton replied that there was nothing wrong with the mortar, that the cement used was 'all fresh Canadian cement,' the sand 'all sharp Chester sand,' and that he had tested the cement repeatedly (Tuck, p. 192).

Taylor and Thompson described salt as the most common form of protection against freezing. Hill and *Radford's* recommended the use of calcium chloride or sodium chloride for protection against freezing. Calcium chloride was also added to accelerate setting and hardening, particularly when making casts and ornamental forms.

3.2.4 Water

At the turn of the century the principal criteria for acceptable mixing water were that it be clean and neither acidic nor basic. Sea water or fresh water were used, although some late 19th-century references cited reservations about sea water. Ransome recommended adding extra cement if the water contained impurities. Taylor and Thompson recommended only that it be free of acids or strong alkalies (p. 35). Hill's comments in 1909 were similar. He particularly cautioned against water contaminated by industrial waste.

Radford's promulgated a misunderstanding of the role of water in concrete in 1909, a widespread view which persisted until the real significance of the water-cement ratio began to be understood in the late 1920s. Water was thought to develop the hydraulic activity of the cement and to allow increased workability and compactibility. It was felt that it was better to use too much than too little. A very wet, soupy mixture was recommended. This belief led to the construction of large quantities of poor quality concrete.

3.2.5 Reinforcement

At the turn of the century the designer of concrete structures had a multitude of reinforcement systems to choose from. Most of the literature on reinforcement focussed on the design of the reinforcement configuration and its arrangement within the structural element. The following quotations were chosen to illustrate the types of reinforcement in use at the turn of the century and some of the issues surrounding its use, such as the problem of rusting.

Although reinforcement was used in ancient times, the principle of its function was first stated in the 1860s. The first American associated with reinforcement design was Thadeus Hyatt in 1880. Reinforced concrete frame construction entered North America at about the turn of the century when Hyatt took out his patents in 1903, which was about 11 years after Hennebique's English patents.

Numerous types of reinforcement were used – hoop iron in the 1840s, wire cable and wrought iron joists in the 1850s and 60s, iron rails from the 1870s and from the 1890s, integrated steel and concrete systems based on wrought bars and wire mesh.

In the construction of his house in the early 1870s, William Ward used round steel rods and structural sections as reinforcement.

> The size of the iron beam, selected for an experimental test, was a four-inch I beam of lightest pattern, twelve feet long, weighing thirty pounds to the yard and its safety load was limited to eleven hundred and fifty pounds.
>
> It is suggested for future construction that an inverted I beam would furnish a more preferable distribution of iron in the composite beams than the I beams which were used (Ward, pp. 108-9).

In 1871 Graham reported on the Prussian army use of railway iron in concrete (Graham, p. 71). This practice was used extensively in the First World War and into the Second World War.

Ransome is credited with inventing the cold-twisted iron reinforcing bar. In the following quotation, he pointed out the advantages of twisting:

> For giving tensile strength to concrete, all modern workers of note now use iron in some form or other.
>
> Angular iron bars, cold-twisted, commend themselves in many ways and on this continent they have been more largely used than any other form in concrete iron construction.
>
> The advantages of this cold twisting are many; they may be summed up as follows:
>
> 1st The tensile strength of iron is largely increased, viz., from 20 to 50 per cent, dependent upon quality of iron construction.
>
> 2d Its elongation under strain is considerably lessened, a very important advantage in concrete-iron construction.
>
> 3d It forms a continuous key with the concrete, both longitudinally and also athwart the bar. The effect of the twist is to grip the concrete in every direction and in fireproof flooring and other work where light construction is desired, the importance of this universal key is very great, for it counteracts the tendency which the bar otherwise would have to split the concrete along the line of tension.
>
> 4th The cost of twisting is nominal and the royalty for its use not prohibitory.
>
> In placing these bars care should be exercised in putting them in position where they will best exert their strength. They should be straight and laid directly in the line of strain. Any deviation from this rule should be such that the tendency to straighten, which invariably occurs upon the application of the strain, will do little or no damage, such a deviation, for instance, as laying the bar of a floor beam with a slight sag in the centre. In such a case when the strain takes place the tendency to straighten would have the effect of thrusting the centre of the bar upward against the downward thrust of the load and it would be harmless. If, on the other hand, the bar was laid crowning in the centre, upon the floor being loaded, the tendency of the bar to straighten would be in the same direction as that of the downward thrust of the floor load and the consequences would be detrimental, if not fatal, to the integrity of the structure.
>
> Concrete is an excellent conservator of iron. Von Emperger states that he knows of a case where iron rods were found perfectly rust free after having been imbedded in concrete below the water level for forty years (Ransome, p. 158).

Ransome went on to reaffirm that iron encased in concrete would not rust.

Kidder advised that the twisted bars were worth the cost of the royalty to Ransome.

The following quotation from Kidder seems a bit naive for 1896. It may be evidence of the time lag between North American and European practice.

> Iron rods, old iron or steel, may be imbedded in the walls, floor and ceilings to as great an extent as may be deemed necessary; these, being firmly held by the concrete, will be very difficult to cut or remove (Kidder, p. 367).

The Canadian Contractor's Handbook was also timid in its recommendations for reinforcement.

> Concrete lintels should then be placed across the spaces between the tops of the piers. These lintels should have widths equal to the width of the ordinary foundation under footings, the depth varying

> with the weight to be carried. The insertion of small steel or iron joists within the lintels adds very considerably to their strength (p. 18).

Taylor and Thompson were much more thorough. Not only did their text list several different reinforcing systems, but also included recommendations for placing and thickness of cover.

Little advice existed for the contractor on the installation of reinforcement until C. Hill published his text in 1909:

> See that the steel is cleaned from loose, scaly rust; a thin film of rust is not objectionable. See that the steel is free from oil or paint, both lessen the adhesion of the concrete. See that all adhering dirt is cleaned from the steel. See that concrete which has lodged on the steel and hardened during previous work is entirely removed before the reinforcement is finally concreted in.
>
> See that the bending of bars is done in such a manner that they do not break or crack at the bend. The bending force should be applied gradually and not with a jerk. Cold bending is always preferable; if hot bending is allowed see that the bending is not so done that the bar is weakened or burned (Hill, pp. 43-44).

He also recommended that reinforcement be tied at junctions with No. 16 and No. 18 gauge soft black wire and that templates be used "... to ensure that bars in columns are accurately spaced top and bottom" (Hill, p. 46). To splice bars, Hill recommended butt joints in screw clamped sleeves.

3.3 TOOLS, EQUIPMENT AND LABOUR

The type of equipment and the amount of labour used on construction sites varied with the scale of the project. It could range from one man with a mixing platform, shovel, barrow and rammer to a large crew operating a complete steam-powered production plant. The design of concreting tools and equipment varied little during this period. The greatest change was in the wider use of power mixers, a proliferation brought about by their increased portability.

Taylor and Thompson advised against economies in labour. They recommended using all the labour necessary to ensure a smooth continuous operation of the work.

> The best plan, where the size of the gang can be regulated to suit, is to give each man a single operation to perform. For example, let one man or set of men wheel and measure all the sand; let another set of men mix the sand and cement; let a third set be continually employed measuring the gravel or stone; a fourth mixing the mass, while one or two of their number supply water; a fifth filling the barrows and wheeling the concrete to place and still another set leveling the concrete and ramming or puddling.
>
> It is generally economical to have two batches of concrete in preparation at once, although one set of men usually can measure and mix the sand and cement for two mixing gangs. While one batch of concrete is being shoveled to place or wheeled in barrows, the other batch, either in a different location on the same platform or on a separate platform, may be spread and mixed (Taylor and Thompson, p. 348).

Taylor and Thompson also described the equipment needed for concrete sidewalk construction.

> The following implements are required in ordinary concrete walk construction:
>
> Mortar box for mixing the materials for wearing surface.
> Platform about 12 ft. square for mixing concrete...
> One or more iron wheelbarrows for handling the materials and the concrete...
> Square-pointed shovels...
> Hoe.
> 2-inch scantling of a width corresponding to the thickness of the walk.
> $^3/_8$-inch stuff of same width as scantling, for curved forms.
> Steel square.
> Spirit level.
> Straight-edge long enough to extend across the walk.
> Two rammers about 5 inches square, with handles about 4 feet long...
> Wooden stakes.
> Iron pins and twine for stretching line.
> Mason's trowel.
> Pointing trowel.
> Plasterer's steel trowel...
> Plasterer's wood float.

> Groover...
> Edging trowel...
> Dot roller...
> (Taylor and Thompson, pp. 439-40).

Radford's recommended similar mixing equipment:

> ...the concreting outfit will include the following tools: **Shovels,** No. 3, square point; **wheelbarrows,** at least two being necessary for quick work (sheet-iron body preferred); **rake; water barrel; water buckets,** 2-gallon size; **tamper,** 4 by 4 inches by 2 feet 6 inches, with handles nailed to it... **garden spade,** or **spading tool** cut from a board and beveled to a thin edge at the bottom,... and a **sand screen,** made by nailing a piece of 1/4-inch-mesh wire screen 2-1/2 ft. by 5 ft. in size to a frame made of 2-in. by 4-in. stuff (Radford's, Vol. 6, pp. 157-59).

Equipment available for on-site movement of mixed concrete varied and included wheelbarrows, carts, wagons and derricks.

Taylor and Thompson described a steam powered rammer in 1907 which could only have been suitable for very dry mixes and thin layers of concrete such as those used in pavements. Hand rammers were far more common, however, for both dry and "mushy" concrete. A variety of these tools were available.

While *Radford's* also described the powered tampers, they devoted more space to the hand variety.

> **Pneumatic tampers,** operated by compressed air, are used chiefly in connection with concrete block and moulding machines. The **"Kramer" Automatic Tamper** is a power machine usually driven by a small gasoline engine or motor. The tamping is done by a gang of tamper hammers, which consist of detachable wooden blocks connected to eccentrics mounted on a revolving shaft and so set around the shaft that as some of the tampers are coming down, others are going up. The force of the blows is regulated by a hand lever which is pulled down a greater or less distance, lowering or raising the tampers; and the driving pulley is automatically disengaged when the tamping is done and while the block is being removed from the plate. The machine is especially adapted to rapid work and large output. (*Radford's*, Vol. 6, p. 249).

After cement mixers, hand finishing tools were the most advertised items of concrete construction equipment. The basic surfacing tool was the metal plasterer's trowel, but there were a variety of edgers, groovers and rollers mostly for pavement and sidewalk work. Some manufacturers marketed patented fittings for attaching long handles to these tools and advertised that they allowed the finisher "to work from the other side of a picket fence" (*American Carpenter and Builder*, 1908).

The trade publications also contained advertisements for sidewalk and curbing "kits," including reusable metal formwork and specially shaped rammers and finishing tools.

3.4 TRANSPORTATION AND STORAGE

The techniques and criteria for transportation and storage of materials for concrete construction are straightforward and changed little over the period discussed.

Cement was shipped in wooden barrels containing 380 lbs. of paper or jute sacks containing 95 lbs. By the turn of the century, sacks were replacing barrels except where the atmosphere was harmful and long periods of storage were anticipated. Although some waste, caused by cement clinging to the inside of jute sacks occurred, these were preferred over paper because they were more durable.

The most important criteria in storing cement was dryness because cement absorbs moisture from the atmosphere. Several references advised against using cement immediately on receipt. Instead they recommended a period of air slaking, probably to prevent the free lime from slaking after it had been mixed and placed.

In 1857, Captain Scott recommended not only storing the cement but also drying it protected from the air. In 1861 he allowed that cement could be shipped and stored in bags if it was to be used quickly.

Butler described poor storage conditions in 1895 as a frequent source of problems with freshly manufactured cement. He felt proper cooling and aeration were essential.

Taylor and Thompson reiterated the need for dryness and noted the positive aspects of aeration on fresh Portland cement. They suggested that sand and aggregate be stored as closely as possible to the mixing platform.

Hill's description of ideal cement storage on the building site is more detailed, but probably unrealistic. He suggested protection from heat as well as dampness, good ventilation and storage in properly labelled bins for each shipment, easily accessible for marking, inspection and removal. *Radford's* advocated cloth sacks for Portland cement because they were more tear-resistant than paper bags and lighter than barrels.

3.5 TESTING

Although it was recognized that the strength of mortar or concrete was influenced by a number of factors besides the cement, it was understood that cement quality was important. Thus, methods for testing it on site were devised. Among these were tests for fineness of grinding and specific gravity. However, the main criteria for judging cement were the time required for hardening, soundness during hardening and tensile or compressive strength. Throughout the second half of the 19th century on-site testing of cement and sometimes the other materials, was an essential part of the construction process. In the 1870s inspection and testing criteria on large projects were precisely detailed. By 1910 testing procedures were simplified and were included in project specifications. However, even in the first decade of this century text books on concrete still warned users to test materials if they were not from a reputable manufacturer.

In his 1850 text on foundation construction, Dobson described use of the Vicat needle for testing the hardness of cement samples.

Major Maquay, quoting from the specifications used for coastal batteries at Cork Harbour in 1873, noted that fineness, weight and tensile strength were tested on-site. Ransome, who wrote briefly on cement testing in 1894, emphasized determining hardening, fineness and tensile strength.

On the Trent Canal project the following tests were used:

> All cements were subjected to the following tests: – Colour: the cement to be a uniform quality and of a light grey tint, after being made into thin cakes and exposed to the air and in no case must it show

Courtesy of the National Archives of Canada

> yellowish blotches. Weight: the specific gravity to be not less than 3.1. Tensile strength, per square inch of section, to be as follows: neat cement after three days 250 lbs., seven days 400 lbs., twenty-eight days 550 lbs. Fineness: all cement to be ground of such a fineness that 90 percent of it passes through a sieve of 10,000 holes to the square inch. Soundness: this was determined by the Faija apparatus. All pats when subjected to a moist heat of 110ºF and warm water, to show no signs of blowing, for 24 hours after the tests where begun.
>
> Six samples of cement were taken from each car as soon as it arrived in Peterborough and these had to pass the following tests, viz., sifting, specific gravity and blowing, before the car could be sent to the contractor's siding, where it remained until the three-day test for tensile strength had been made (Greenwood, pp. 87-88).

Kidder, writing in 1896 was less precise on testing. He appeared to place more emphasis on supervision and an honest contractor.

Taylor and Thompson's recommendations regarding testing varied, depending on the type and size of the project:

> If the job is small and unimportant, it is generally safe to select in the market a brand of Portland cement of American manufacture which has a first-class reputation, and to use it without testing. As a precaution, however, it is usually advisable that samples from a few of the packages of every shipment be tested for soundness. This can be done after a little practice with scarcely any apparatus. For very important concrete construction complete specifications should be prepared before purchasing the cement, and a small laboratory established for conducting tests to determine whether it is fulfilling the requirements (Taylor and Thompson, p. 12).

Hill had a cynical view of the honesty of some manufacturers and was a strong advocate of on-site testing. His advice to inspectors regarding testing is extensive. He also described tests for sand and aggregate. Most tests, such as mineral composition, were done in the laboratory but he included on-site techniques. The shape of grains of sand was determined with a magnifying glass, the sharpness by "feel," the size by sieving and the cleanliness by agitating the material in clear water and allowing the dirt to rise to the top.

Radford's included simple materials tests for its readers:

> Simple method of testing by which the user may ascertain the soundness of the cement he proposes to use, is as follows
>
> Make three cakes of cement, thicker in the middle than on the edges. Allow one to remain in moist air for 24 hours, and then steam it 4 hours. The second cake should be exposed in moist air, and the third be immersed in water. The results in the case of the second and third cakes should be noted at intervals during 28 days. If the cement is sound, it will not disintegrate; but if it shows expansion cracks on the edges of any of the cakes, it is not sound (*Radford's,* Vol. 6, p. 134).

4.0 SITE PRACTICE

In concrete construction the designer usually specified the proportions in which the components of the material should be mixed. These were defined by volume, weight or parts, for which the contractor could use his preference. For example, in 1837 Captain Alexander of the Royal Engineers set down his specification for cement made with hydraulic lime.

> **Proportions -** The proportions of the materials, are seven parts of gravel and sand mixed as above, one part of lime, and one part and a half of boiling fresh water. Some judgment is necessary here also, for the quantities of water and lime vary occasionally, according to the dryness and quality (as to fineness) of the gravel. The finer the gravel, the more lime is necessary, and the drier it is, the more water is required (Alexander, p. 36).

The theory of grading and proportioning in the late 19th century was basically that the sand would fill the voids between the stones and the cement paste would fill the remaining voids. The result was a dense conglomerate composed of supposedly perfectly filled voids. The investigators of the period were, however, aware of the practical problems with this theory. First, if the voids are calculated to be perfectly filled with a 1:2:4 mix, they will not be filled with a 1:3:6 mix and there will be excess cement when using a 1:1:2 mix. Second, they did not agree on a method of calculating voids.

The question of water content had not yet been considered; however, it is described here because it is one aspect of late 19th-century construction technology which had a significant bearing on concrete durability.

Classic advice had been "good mortar should be tempered only with the sweat of the mason." Although generally recognized, there have been deviations from this view by both builders and investigators. Late in the 19th century a wet mix seemed to offer several advantages over a dry mix and was easier to place, being less likely to segregate. Most of all, it was thought to be denser and therefore stronger. The importance of the amount of water for strength was only beginning to be understood in the early 1920s.

Because the theory of proportioning and the evolution of proportioning "rules" is beyond the scope of field practice, the following references will refer only to the methods of measuring and other related questions of interest to builders.

Late 19th-century military engineers were well aware of the need to mix concrete dry. For example, Ardaugh wrote in 1866:

> The revetments are to be of concrete, composed of one part of Scott's cement, one part of coarse, clean, sand and six parts of ballast shingle or flint, mixed properly dry; a sufficient quantity of water to be added just before and as it is required for the works (Ardaugh, p. 161).

Eight years later Maquay noted:

> The quantity of water required for mixing with the dry ingredients to form a concrete, will vary with the season of the year and the characteristics of the materials used; some judgement is therefore requisite in adding the water. The following is a good practical guide. The water added should only be sufficient to moisten the ingredients and must not be allowed to flow over the surface of the mixing board or to run down the sides of the heap that is being mixed, for if it does flow down, it washes away the cement and fine particles of sand from the surface of the broken stones or coarse materials and impoverishes the concrete.
>
> If any water comes to the surfaces in the first operation of ramming, it must be soaked up with a dry water brush, otherwise it will percolate through the concrete before it sets and depressions will be left in the floor; it is for this reason that the materials should be mixed very dry (Maquay, p. 146).

In the same article Maquay described the gauging frame for measuring out quantities.

> A convenient size for this frame is a square box, open at top and bottom, of 5 ft. 6 in. sides and 1 ft. 4 in. deep. The gauging frame is put at one end of the stage and broken stone is shovelled into it to a depth of 12 in. and then a quantity of sand, sufficient to fill the remaining four inches; to these are added two sacks of cement, each containing two bushels (if received well filled from the manufacturer, they should contain that amount). By adopting a frame of the above dimensions and by using two sacks to the frame full of other materials, a proportion of 1 of cement to 8 of other ingredients is obtained and the necessity of measuring the proportion of cement is avoided. The bulk of concrete that these quantities of aggregates will produce is one-and-a-quarter yards cubed (Maquay, p. 139).

Ward described his proportioning practices in detail, using various grades for different parts of the structure. The concrete was mixed with "only sufficient water to give it the consistency of well-tempered moulding sand" (Ward, pp. 108-10).

In *Portland Cement for Users*, H. Faija recommended using minimum water for maximum strength of concrete. He also highlighted a number of other points to consider, among them the water-absorbing properties of the aggregate.

Ransome, however, took issue with the low water content school. He argued that wetter concrete was easier to compact and would therefore make better concrete. Although he admitted that a minimal quantity of water gave the best result when preparing briquettes for testing, he argued that the situation was quite different when large quantities of gravel and crushed stone aggregate were involved. Ransome may have been responsible for the widespread use of "soupy" mixes over the next ten to twenty years.

Kidder revealed an interesting difference between the quantity of cement specified and the quantity that actually was put into the mixer on the job site:

> The method of making and using concrete is very simple, but owing to the fact that it is impossible to tell

> from an examination of the product the amount of cement that has been used and the great temptation to the contractor to use as little cement as possible, not more than one-half or two-thirds of the amount of cement specified is generally used (unless an inspector is kept on the work) and the mixing of the materials is also often very imperfectly done (Kidder, p. 119).

Kidder recommended measuring the proportions of materials by volume:

> The only proper way to make concrete is by carefully measuring the proportions of cement, sand, broken stone, etc. This may readily be done by using the common mason's wheelbarrow for a unit of measure and mixing together the specified number of barrows of each material (Kidder, p. 120).

He also provided a rough guide for calculating the sand required to fill the voids and suggested that an inspector could tell by the appearance if the amount was correct.

Measurement of cement by weight and sand and aggregate by volume was recommended by Taylor and Thompson in 1907. They suggested using exact units of measurement, such as cubic feet, to define terms such as "part" or "barrel." They also suggested using gauging frames similar to those described by Maquay for proportioning the materials.

Taylor and Thompson were aware, by 1907, that the amount of mixing water influenced the ultimate strength of the concrete. Their advice, however, was as follows:

> The experiments of the authors show that while dry concrete, very carefully mixed and rammed, is stronger on short time tests, medium mixtures will attain nearly equal strength in six months' time. One of the arguments against very dry mixtures is the difficulty of obtaining a uniform consistency. Occasional batches will invariably be too dry and it is impossible with ordinary care in placing and ramming to avoid visible voids or pockets of stone which form weak places and allow the penetration of water (Taylor and Thompson, p. 372).

They quoted a 1903 specification of the American Railway Engineering and Maintenance-of-Way Association:

> The concrete shall be of such consistency that when dumped in place it will not require tamping; it shall be spaded down and tamped sufficiently to level off and will then quake freely like jelly, and be wet enough on top to require the use of rubber boots by the workmen.
>
> A very wet mixture is more suitable for rubble concrete or concrete rubble because the large stones more readily settle into place and bed themselves. In thin walls very wet concrete can be more easily 'joggled' into position so as to conform to the molds and give a smooth surface. The use of a mixture sufficiently wet to flow under and around metal reinforcement has been found by Prof. Charles L. Norton… to be one of the essentials for the preservation of the metal (Taylor and Thompson, pp. 372-73).

One of their sample specifications provided descriptive definitions of mixes of various water contents:

> **Consistency.**
> (a) A medium or quaking mixture of a tenacious, jelly-like consistency, which quakes on ramming, shall be used for ordinary mass concrete, such as foundations, heavy walls, large arches, piers, and abutments.
> (b) Very wet or mushy concrete, so soft that it must be handled quickly or it will run off the shovel, shall be used for rubble concrete, and for reinforced concrete, such as thin building walls, columns, doors, conduits, and tanks.
> (c) Dry concrete, of the consistency of damp earth, may be employed in dry locations for mass foundations, which must withstand severe compressive strain within one month after placing, provided it is spread in 6-inch layers and rammed until water flushes to the surface. Dry mixed concrete shall never be employed with steel reinforcement (Taylor and Thompson, p. 35).

Radford's in 1909 contained almost identical definitions of "very wet" "medium" and "dry" mixtures and their uses. The following is from Hill:

> This gives the per cent by weight of water required. When "soupy" concrete is specified, the soupy consistency of thick broth is meant (Hill, p. 16).

Regarding accurate measurement Hill's advice was:

> 1. that definite measuring units be employed; 2. that the accuracy of the measuring boxes, hoppers, etc., be

> verified; 3. that the filling of the measuring boxes, hoppers, etc., be exact and 4. that, when two or more box or hopperfuls, etc., go to make up a batch, the exact number is employed for each and every batch. The inspector should bear in mind that while splitting hairs is not warranted by the exactness of the process of concrete making as it is conducted in practical construction work, slipshod and careless methods and practices should not be tolerated (Hill, p. 17).

In his advice to field inspectors, Hill concentrated on errors brought about through incomplete filling, miscounting and loose or packed volumes.

Machine mixers with automatic measuring devices were marketed in the first decade of this century. Hill recommended carefully regulating them and keeping the feed hoppers unclogged and continuously supplied with material.

4.1 FORMWORK

The references regularly commented on formwork:

- the expense and skilled labour required in its construction
- the importance of constructing formwork with tight joints to avoid leakage of mixing water and cement
- the importance of solidity, particularly to avoid dislocation from placing equipment and
- the selection of suitable release agents such as crude oil, kerosene, grease, soap or linseed oil

Formwork was usually custom-built from wood to suit the specific job and was described as a major cost of concrete construction. It is not surprising that reusable formwork, usually metal, appeared very early (late 1860s in Britain), but its use was not widespread at the turn of the century except for sidewalk and pavement construction. The technique of moveable formwork for retaining wall construction also appeared in the late 1860s.

The following quotation is the earliest reference documenting the construction of a concrete arch, in this case an experimental casemate built by the Royal Engineers at Woolwich in 1837. Note the importance the writer gives to finishing a "lift" in a working day:

> Framework and Centering – This description of concrete sets with great rapidity; so fast, that a box or mould four feet long, three feet by one foot, filled with this material, turned out quite solid from the box in less than ten minutes. It expands also considerably while setting; these effects make it necessary that in building with this material, the frame-work which gives the shape and dimensions of the walls and arches, should be firmly secured and braced.
>
> It is important that all the joints vertical to the courses be made square and at the periods of leaving off work, not to commence more than will be sufficient to build to a joint, by the time of leaving off (Alexander, p. 36).

In 1865 Lieutenant Ardaugh supervised construction of a coastal defence fort at Newhaven, England. The ditch walls were concrete, the first British military use of the material in such large quantities.

> The contractor to provide all the necessary boarding for the face of the wall, which is to be fixed to such lines, slopes or batter, as may be required; and it is presumed that sufficient boarding to raise the wall three feet high is all that will require to be fixed at one time, care being taken that the lower edge or starting, upon the last layer, shall, in all cases, be well secured and neatly fixed, so as not to show an offset on the face of the wall.
>
> Each piece of boarding is composed of three or four 12-inch deals, wrought on one side and edges, bolted through and ledged at the back, with a staple, ring and rope at each end to attach it to the standards.
>
> These boards are wedged up into their exact position from the standards, which are strutted or, when the work becomes high, are tied to the revetment by wires or pieces of hoop iron, which are subsequently cut off flush with the face. A rougher system is adopted for the back. By this means a perfectly uniform and fair surface like that of rubbed stone can be obtained and when the work is continuous, the joints are hardly perceptible. At first great difficulty was experienced in exacting the necessary care. The chief points which require attention are: that a sufficiency of sand should be used; that the concrete should be thoroughly mixed; that the boarding should be perfectly smooth and plane; and that the ramming be well done. This last has been a chronic source of annoyance (Ardaugh, p. 163).

Permanent formwork of wood or hollow clay tiles was a common component of several late 19th-century fireproof flooring systems. The Fox and Barrett floor, patented in 1844, was one. It was incorporated in a supplement to the 1859 specification for the East Block on Parliament Hill, Ottawa.

> Lay throughout the floors, fillets of deal about 1-$^1/_2$ inches square resting on the flanges of the iron joists, placed nearly closed together to receive the pugging (DPW).

Two layers of concrete 4-$^1/_2$ inches deep was placed on the fillets, encasing the iron joists.

Colonel Graham described in 1871 the Prussians' use of railway iron (rails) as permanent formwork and reinforcing (Graham, p. 71).

For the construction of his house at Port Chester, New York in 1873, William Ward chose concrete because of its proof against fire. His description of formwork for beam and floor construction is fairly typical for the period:

> A plank mold was made the length of the iron beam, twelve inches deep by five inches wide, in the bottom of which a layer of béton was first moderately tamped down to an inch in thickness; then the iron beam was laid on the course at equal distances from each side of the mold and settled down on the surface of the course of béton to a good bearing. This brought the top surface of the beam seven inches below the top of the mold. The work of filling and tamping the courses was then continued until the mold was filled.
>
> When the combination beams were completed and ready for the floors and roof, heavy planks were firmly placed in position and securely supported between the beams; the upper surface of these plank foundations being adjusted on a level with the top surface of the molded beams. These planks served as the bottom of the floor molds and after the béton comprising the floor was hardened they were removed.
>
> Channel ways had been molded in the walls, on a line with the top of the beams, for the purpose of supporting the outer edges of the floors (Ward, p. 108).

Major Maquay of the Royal Engineers published a paper in 1874, significant for Canadian military construction. It is based on the author's experience constructing gun emplacements and buildings similar in design and materials to those on Canada's east and west coasts.

> Concrete can be laid or moulded to any form by means of sheeting, panelling and centering. Attention must be paid to the joints of the sheeting, to see that no moisture runs out between the planks, for any water getting away from the concrete, takes a portion of cement and sand with it and on removing the sheeting, cavities will be found where the joints have been left open. Some whitening and plaster of Paris mixed in equal proportions, makes a good stopping to lay over the joints.
>
> When 3-inch planks are used for sheeting, the distance apart of the struts or guides supporting them should not exceed 7 feet; above this distance planks of this thickness will spring or bulge outwards to the weight of the concrete and the pressure of ramming. (Maquay, p. 141).

Maquay also described moveable formwork used in constructing ditch revetments which involved a stage on truck wheels and a moveable tramway to which plank sheeting was attached. He suggested that concrete arches could be built using either the ordinary centering used for brick arches or solid cores built up of earth and stones. He recommended using a double or hollow vault for powder magazines, as a precaution against dampness.

While describing hut construction, Major Maquay noted an early application of the principle of reuseable formwork using cast iron plates of convenient sizes with bored flanges to receive bolts and nuts. He also mentioned cast-in rebates for window and door joinery. He recommended that all sharp corners be rounded off or chamfered, using plaster of Paris and whiting or fillets of wood, in the corners of the formwork.

The cost of formwork construction was one of the main obstacles to using concrete in general construction. Ernest Ransome, a prolific contributor to concrete construction, drew attention to the problem and suggested standardized centering and cribbing whenever possible.

Ransome recommended coating the formwork with common thick kerosene oil before use and a fresh brush coat of oil or a paste of castile soap and water before each use. In 1896, F. Kidder recommended applying a hot solution of soap before each pour.

Gang of Workmen Laying a Five-Foot Sidewalk, from Radford's, Vol 5.

The Trent Canal and the locks at Sault St. Marie were the first major waterways facilities constructed in Canada which primarily used concrete. The formwork was three-inch plank supported by braced frames at five foot centres. The back face of the lock walls was braced against the face of the excavation; for higher bridge embankments, the back moulds were held in place by iron rods passing from the front of the wall.

In their textbook of concrete construction, Taylor and Thompson stressed the need for stability and watertightness in formwork construction. They suggested using wires to connect the two sides of the casing and twisted with a stick which acted as a turnbuckle to tighten the wires.

They recommended crude oil as a release agent but they also mentioned thin soft soap, a soap and water paste and strong packing paper soaked with linseed oil as alternatives.

By 1907 the removal and raising of formwork had been considerably simplified by the use of ribbed casings with greased bolts that were withdrawn before the concrete was hardened and by moving the casings up half their height.

The American Steel and Wire Co. 1908 catalogue included notes on the construction of formwork, emphasizing the quality of finish, unlike the concerns of the earlier authors. Various methods, including wedged edges, pointing with hard soap, putty or oakum and sheet metal liners, were suggested to reduce the imprint of the formwork on the finished surface.

Charles Hill, in his 1909 handbook for inspectors and site supervisors, repeated earlier advice on accurate, tight formwork and the proper use of release agents. He noted, however, that the use of grease or oil should be avoided if the wall is to be plastered or whitewashed. Hill recommended the two methods previously described for keeping forms parallel: twisted wire ties with wood spacers and heavily greased bolts.

The publishers of *Radford's* in 1909 gave advice on formwork, indicating that formwork design was being taken as seriously as the design of the structure itself. This may have been connected with several formwork collapses in the 1900-05 period. *Radford's* noted:

> The cost of construction as a whole is as likely to be governed by the cost of the forms as the cost of the concrete....

> In building construction where the forms form a large percentage of the cost of the building, and where a failure in the forms may cause loss of life, it is especially necessary to treat this question from an engineering standpoint, and many of the best concrete contractors now design their forms as carefully as the dimensions of the concrete members (*Radford's*, Vol. 5, pp. 3, 5).

With regard to release mediums, *Radford's* recommended crude oil first, then linseed oil, soft soap. Forms to be left on until the concrete had hardened, according to the work, required only a thorough wetting (*Radford's*, Vol. 5, pp. 11, 12).

4.2 MIXING

The principal techniques used for mixing concrete were by hand and by steam or gasoline powered machines. Hand powered machines were also available. Hand mixing was abandoned by the 1870s on large projects in favour of centrally located, steam powered crushing and mixing stations, but it continued to be extensively used in smaller construction jobs well into this century. Contractors were advised to select the appropriate mixing technique to match the continuous concrete requirement of the project.

Powered mixers had several advantageous features which went beyond the rate of production and thoroughness of mixing. They were as efficient at the end of the day as they were at the beginning, unlike most human mixers. They brought power onto the site which could be used for other purposes such as powering winches, endless belts and stone crushers. Indeed most references recommended that there was little benefit in mechanizing the mixing process if the processes before and after were not also mechanized.

Advertisements placed in the *American Carpenter and Builder* were tabulated to discover the extent of machine mixing. The May 1908 issue advertised six machines made by six companies. The April 1916 issue had 41 mixers manufactured by 29 companies which emphasized automatic proportioning and self-contained power.

The earliest reference to a central mixing plant distributing prepared concrete to several construction sites was dated 1904 in St. Louis. Horse carts were used to transport the concrete.

In the first half of the 19th century the usual method of mixing was by hand with shovels on a specially prepared mixing platform. As required, the platform was moved from place to place on the site. This was the procedure used in the construction of the escarp walls at Newhaven in 1865.

Although hand mixing continued to be widely used, the process was soon mechanized. Major Maquay described the advantages of each method:

> Concrete can be mixed by hand or by means of steam machinery. The first method is convenient when there is ample space, materials in quantity close at hand and cheap labour; but concrete is mixed by machinery more uniformly, rapidly and economically, than by hand (Maquay, p. 139).

He then described the requirements and procedure for hand mixing:

> In mixing by hand, a boarded stage or floor is required, about 8 ft. wide and 15 ft. long and a frame for gauging or measuring the ingredients.
>
> After the ingredients have been placed in the frame, it is lifted off the heap by means of handles on the sides; the dry materials are then turned over to the other end of the stage or mixing board by two men, with square mouthed shovels, working towards each other along one side of the heap that came out of the frame. Care should be taken to make this turned over heap of the same form as the original one, for if worked up to a pile, the larger stones will roll to the foot of it. Two other men with shovels will commence at the end of the new heap and turn over about a barrow load of the material at a time, while a third man adds the water, by means of a watering-pot fitted with a rose. Too much attention cannot be paid to the rose being invariably used for this operation, for if the water is poured out of a spout, hose or bucket, it will scour away the cement from the stones and sand. After the operation of watering, the moistened barrow-load can be shovelled into wheelbarrows or other means of transport and is then ready for laying in the work (Maquay, p. 139).

And machine mixing:

> The form of mixer commonly used by contractors is driven by steam-power and consists of a revolving hollow cylinder about 3 ft. in diameter and 12 to 14 ft. long, set at an angle of 6 to 8 degrees to the

horizon. The cylinder is usually made of hard wood lagging, lined with sheet-iron, fixed by hoop-iron bands over four cast-iron discs or wheels, keyed on a 3-inch shaft in the axis of the cylinder.

The ingredients are measured in a hopper at the upper end of this cylinder and by its revolutions (which should be 16 to 20 per minute) they are mixed and passed out at the lower end. The objection to this long drum is, that it is difficult to regulate the quantity of water to be added, as the materials are so enclosed, that the state of moisture they are in cannot be judged by the eye.

A much better mixer is a fixed semi-cylinder of wrought or cast-iron, in the axis of which revolves a 3-$^1/_2$ inch square wrought iron shaft, with 3 to 4 blades each side of it, set at a pitch like a screw-propellor; these blades mix and deliver the concrete. The upper end of the mixer is closed, the lower end open, but with a cross bar to take the bearing for the shaft; the cross section of the cylinder should be more than a semi-circle, to prevent the materials being pushed over the side by the blades and the cylinder should be set at a small angle to the horizon.

By using a double hopper at the head of a mixer of this description, the delivery of concrete will be almost constant; for while the ingredients are being measured into one hopper, the other will be feeding the mixer.

The supply of water is served and regulated by a stop-cock and iron pipe, with holes along its bottom, suspended horizontally over the upper end of the shaft and blades.

It will be found that the open mixer, with revolving shaft, delivers concrete into wheelbarrows or trucks, much better than the closed drum and this is a considerable advantage (Maquay, p. 140).

Maquay described a site where an eight-horsepower steam engine drove a mixer, crusher and elevator producing five yards of cement per hour. A second station with a 12 horsepower engine produced 8 yards per hour (Maquay, pp. 140-41).

The sources suggested a variety of views on the extent of mixing required. Some stated that three complete turns was sufficient while others advised extensive mixing.

Like Lieutenant Ardaugh and Dobson before him, H. Faija recommended thorough mixing of the dry ingredients and a carefully regulated flow of water. He also advocated placing the concrete as soon after mixing as possible.

Ransome promoted machine mixing wherever possible. Writing in the *Canadian Architect and Builder* in 1894 he attempted to destroy the myth of "over mixing."

> There is great advantage and economy in mill mixing. Mills can now be obtained at a reasonable figure and should always be used on large works. By their use the cement is more fully utilized, the cost of labor lessened and the work is more uniform and satisfactory in character.
>
> An objection is often made to mill-mixed concrete, viz., that the concrete is injured by overmixing. What is "overmixing?" I have never once met with it, although I have been actively engaged in concrete construction for thirty-five years (Ransome, p. 159).

In the same periodical, Greenwood stated in 1897 that both methods had been used on the Trent Canal work. He also described each process. The machine mixer was a cubical sheet-iron box revolving on its diagonal. Ingredients were added to it from measuring containers poured through hoppers.

In 1896 Kidder described the advantages of machine mixing and the necessity for thorough mixing. He cited various tests which indicated that machine mixing can double or even quadruple the ultimate strength.

Like earlier writers, Taylor and Thompson stated that quantity determined whether hand or machine mixing should be used. Cost per cubic yard should be determined for both methods. Apparently hand mixing had not lost favour because they then described the technique in detail including several improvements in efficiency. They included the following sample specification for hand mixing.

> **9. Hand Mixing.** If the concrete is mixed by hand, the cement and aggregate shall be mixed and the water added on a tight platform large enough to provide space for the partially simultaneous mixing of two batches of not more than one cubic yard each. The sand and cement shall be spread in thin layers and mixed dry until of uniform colour. This mixture may be spread upon the layer of stone shoveled upon it before adding the water, or it may be made into a

> mortar before spreading it with the stone. In the former method the materials shall be turned at least three times, – in addition to the mixing of the sand and cement already mentioned, the water being added on the first turning, – and in addition to the shoveling from the platform to place or into the vehicle for transportation. In the latter method, that is, if the sand and cement are first made into a mortar, the mass of mortar and stone shall be turned at least twice. Whatever method is employed, the number of turnings shall be sufficient to produce a resulting loose concrete of uniform colour and appearance, with the stones thoroughly incorporated into the mortar and the consistency uniform throughout (Taylor and Thompson, p. 35).

Discussion of machine mixing in Taylor and Thompson's text is too long to be included here. For a full description of machine mixing in 1907, the original text should be consulted. They state that the mechanization of the processes before and after mixing encouraged conversion to machine mixing. Also, stationary or portable equipment could be adapted to the needs of the particular job.

Trade publications of the first decade of this century advertised mixers featuring automatic proportioning of materials. Taylor and Thompson cautioned against automation when methods of volume were used, because of the inaccuracies of measuring cement by volume. They advised that a trained gang of men with shovels would give more reliable results.

Hill, in 1909, had little to add to the discussion on machine mixers already covered by Taylor and Thompson. Both sources favoured batch mixers over continuous mixers where uniform and well-mixed concrete was required, because of the difficulty of uniform feeding. If continuous mixers were to be used, Hill recommended pre-proportioning the dry mix.

Radford's was less cautious than Hill about hand mixing if the economics of the job warranted it, but they stressed the need for supervision. Like Taylor and Thompson, *Radford's* said that machine mixing would not produce significant economies unless it was coupled with mechanization of the processes before and after mixing.

4.3 MOVING, PLACING, COMPACTION

Several methods and types of equipment were used to transport mixed concrete to where it was required, to place it and to tamp or compact it.

The sources indicate that the main issues regarding this part of the construction operation were:

- avoiding segregation of large aggregate from the mass during placement
- importance and method of bonding freshly placed concrete to concrete that had already set.

In the late 19th century concrete was laid in short "lifts" for which a relatively dry mix was used. After the turn of the century, walls were cast continuously, full height, a technique which required a very wet mix for ease of placement.

Captain Alexander described the placing of concrete during the construction of an experimental casemate at Woolwich. It should be noted that the cement set very rapidly.

Courtesy of the National Archives of Canada

> **Method of Building –** When the concrete is thus sufficiently mixed, it is immediately dashed with shovels into the part of the building carrying on where it is received by two men with rammers, who ram it close together, so as to secure equal consistency (Alexander, p. 36).

On the construction of foundations made with chalk lime cements or hydraulic lime cements, E. Dobson advised:

> Force the concrete into the trenches, ramming it continually, so that it shall exert considerable lateral pressure. It is a common practice with contractors to make the concrete course exactly of the specified width, irrespective of the extent to which the trenches have been excavated and where any vacuities occur, to keep up the concrete temporarily with boarding, which is removed as the concreting advances and the vacant space is filled with loose earth and punned or not as the chance may happen. **This is most improper practice**.
>
> The inspector should require that the whole extent of excavation should be filled in with concrete and that, if the trenches are got out too wide, they must be filled up with concrete at the contractor's expense. If the sides of the foundation-pits are carefully trimmed and the concrete punned up solidly against them, the success of the work will be in a great measure independent of the cementing properties of the lime and the gradual consolidation of the mass will be an additional source of security (Dobson, p. 40).

He also commented on other poor practices in the placement of concrete, particularly that of throwing concrete, which separated and aerated the mix. He recommended successive layers of no more than 12 inches.

Dobson's book dealt exclusively with foundations and heavy marine works and it described techniques for submarine placement of concrete.

The role of water in bonding cement to a substrate was described by H.Y.B. Scott, inventor of Scott's Cement:

> The surface to which it is to be applied, particularly if the brickwork be old, must be well wetted. If the precaution be not attended to, the cement is robbed of the water which is necessary to its becoming a solid mass and crumbles for the wall. The effect will occur within one or two days of its being put up (Scott, p. 148).

Scott's Cement was used for the construction of Newhaven Fort in 1865. The specification described the procedure for placing the concrete:

> To be laid in courses 1 foot high and rammed as laid to form the wall, care being taken to prevent large stones from running to the front; and a shovel to be worked up and down between the front of the concrete and the boarding which supports it, so as to bring the mortar to the face. Each of the 12-inch layers to be allowed a sufficient time to harden before another is put on and in no case shall more than three layers be allowed to follow before the under portions shall have become perfectly hard and consolidated. The fitness for the re-commencement of the work in each case to be decided by the superintending officer (Ardaugh, p. 161).

From Ardaugh's description and specification it is evident that construction is being executed in courses used in masonry. A very dry mix was used for the work and it was allowed to set between lifts of the formwork. Movement of mixed concrete was apparently by barrows, although the mixing platform was probably located close to where it was required.

Where a central mixing plant was used, Major Maquay advised using tramways on laid tracks to distribute materials.

Maquay evidently coursed the concrete in lifts like Ardaugh; however, he used a wetter mix and paid more attention to achieving a bond between adjacent lifts. This bonding was achieved by ensuring a rough surface and removing of the laitance or milky substance rising to the top of the mix during ramming. He recommended that the ramming be "gentle."

In recommending rubble concrete for massive work, Maquay emphasized the rodding of concrete around the boulders and keying between layers. He also described the operation of spading large aggregate back from the face of the forms. This was done by running the blade of a spade or trowel along the face of the form, which pushed back the stone and gravel and created a smoother finish surface.

Placing the concrete floor slabs in W. Ward's fireproof house was more precise and probably expensive. It involved an initial one-inch course, the setting of the reinforcement in a second two-inch course and finally a finish coat of finer grade, half an inch thick.

Two layers 4-1/2 inches thick placed with careful tamping between, but without mesh reinforcement was specified for the East Block, Parliament Hill.

Henry Faija, like Dobson, condemned the practice of dropping mixed concrete from a height, for the same reasons. F. Kidder also cautioned against dropping concrete from a high level and recommended adequate ramming soon after placement.

Ira Baker in 1890 gave an early reference to bucket placement and a useful description of ramming. He warned against allowing the ramming to be too severe or prolonged. This text also offered advice on submarine placement, including an early reference to the use of the trémie, a long tube adjusted to the depth of the water through which the concrete mix could be fed. The trémie was partly designed to avoid laitance forming between layers, as Maquay had discussed earlier.

Regarding movement of materials on the site, Kidder described a system which used a central elevator with runways to each floor level as required and another using a travelling crane and buckets.

H. Greenwood, discussing the Trent Canal work, described an alternative technique to spading which involved using a differently proportioned mortar adjacent to the forms to achieve a good finish. For submarine placement, a type of trémie apparatus was used.

E. Ransome gave more detail on the use of a facing grade of concrete. He also made the surprising recommendation to delay between mixing and placing:

> In placing concrete it is preferable to have it of one uniform consistency throughout the mass. In cases, however, where it is required that the face of the work should be of a finer grade, both grades should be carried on simultaneously, the face grade being placed up against the sheeting or mold a little in advance of the backing by means of a trowel or other convenient tool. In more careful work thin strips of iron about six inches wide and of any lengths convenient, may be set up on edge. The face concrete should then be inserted between the mold face and the iron while the backing is placed at the other side thereof. As each layer is put in the iron is drawn up a few inches, so that when the concrete is tamped the effect of the tamping is conveyed below the lower edge of the iron and causes the two grades of concrete to become thoroughly united and monolithic.
>
> The material should in ordinary cases be placed in thin layers, seldom greatly exceeding in depth the length of the largest aggregates used and these layers should follow one after another sufficiently quickly so that one layer does not become stiff or partially set before the next is upon it.
>
> Contrary to the almost universal opinion, Portland cement is improved by a delay between mixing and placing. I have experimented with several brands of Portland cement and find that they were invariably improved in tensile strength by a delay of from one to four hours between mixing and placing (Ransome, p. 159).

Ransome also provided details on bonding old and new work which involved stippling the surface and then adding a cement-lime paste just before the next pour.

Ransome believed that freshly laid concrete could not be compacted too much. His own firm used rollers, but he admitted that this was not common practice.

The Canadian Contractor's Handbook of 1898 recommended narrow layering, of six or twelve inches. Taylor and Thomson, in 1907, suggested six inches as an average when a reasonably dry mixture was being used. However, they also recognized the trend to wetter mixes, which produced a single mass of jelly-like or even "mushy" consistency. This needed only to be puddled or "joggled" rather than rammed, to expel air and surplus water. Wetter mixes could also be handled with less danger of separation.

Taylor and Thompson repeated the advice on removing the laitance and adding a rich cement paste when bonding old work and new, but then admitted that the joints would be the weak points in terms of a wall's water resistance. As an added precaution, they suggested embedding a tumber on the final surface which, when removed, would provide a key for the next day's work.

Taylor and Thompson made an early reference to the rise of a central batching and mixing plant to prepare concrete for several job sites reported in 1904.

> **A Central Plant.** The establishment of a central plant from which the mixed concrete may be hauled to various points as required may be economical in some cities or large towns. This plan has been adopted in St. Louis, Mo., for concrete and is employed in many places for tar and asphalt paving. The ... machinery... will mix the concrete at a much lower cost than could be done by hand-mixing and the concrete hauled in carts to the work at but slightly higher cost than the hauling of the dry materials. Most Portland cement concrete will not be injured if laid within an hour or two after mixing (Taylor and Thompson, p. 361).

Radford's, unlike Ransome and Taylor, recommended no delay between mixing and placing. It cautioned against any disturbance of the concrete after it has begun to set, a caution raised by a number of earlier commentators.

They advised that when a dry mix was used, "spading" should be done with great care to get good uniform results. By using a medium or wet mix, it was easier to get a first-class finish. Workers were cautioned against prying against the forms with a spade.

The advice of Hill in 1909 is similar to that of others before him: a careful pour, as soon as possible after mixing; puddling of wet concrete with rods or slice bars and tamping of dry and medium concrete in 6 to 8 inch layers; bonding of new material to old by scraping off the surface or etching with acid and adding a cement paste; and using a trémie or bottom-dumping buckets, or lowering in bags for submarine work.

4.4 CURING, PROTECTION AND REMOVAL OF FORMS

Turn of the century investigators were not united in their advice regarding the techniques or, indeed, the necessity to protect concrete from drying during the curing process. Some references advised that formwork be left on and the concrete kept damp for five to six days, while others recommended removing the forms as soon as the concrete had set to promote drying and, presumably, rapid strength gain. Apparently investigators in this period did not understand the setting-hardening-curing process, although they were aware of some factors that influenced it.

> Although the Ranger's Cement used in the construction of the experimental Casemate at Woolwich set very rapidly, hardening took a great deal longer.
>
> I may observe, that the penetration of the shot into the piers, shewed that the interior was still damp and the concrete friable in the hand, from which I am inclined to think, that, in masses, it will take a great time to dry perfectly and till then may be liable to dampness in building, but from the similarity of the material to that used in the old Moorish walls in Spain, it may be expected to harden in the same way, those walls now hardly shewing the effect of shot upon them (Alexander, p. 33).

Dobson made a similar statement regarding cements made from hydraulic lime or chalk lime.

> ... hardening generally does not take place for many months, if at all, although the outer crust may become firm in the course of a few hours (Dobson, p. 40).

Dobson's advice that pozzolana – the source of aluminates and silicates – should be finely ground, is not new. The Romans knew it, as did several early 19th-century cement chemists. Builders and engineers apparently needed to be reminded constantly.

Major Maquay advised that in particularly abrasive conditions, such as sea walls, the form boards should not be removed for a year or more (Maquay, p. 143) even when using Portland cement. For land work his advice was different:

> Panels may be shifted 12 hours after the concrete has been put in, provided that it has not been mixed with much water. After the panels are taken down they must be thoroughly cleaned before being set up again (Maquay, p. 142).

Ward stated that his floors and beams were ready for strength tests in 30 days.

The problem of expansion and contraction cracking during the curing process was raised quite early. Lieutenant Ardaugh incorporated brick joints at the corners of the escarp walls at Newhaven to accommodate movement (unsuccessfully).

The next mention of drying shinkage was found in Ira Baker's masonry text of 1890, where he reported contraction of four percent. Kidder in 1896 recommended false joints in

monolithic construction to localize the cracking from shrinkage. Ransome, in 1894, emphasized the need to keep the concrete moist for as long as possible during hardening.

During the construction of the Trent Canal, forms were left on for a minimum of five days for small walls and several weeks for higher walls. Taylor and Thompson suggested removing forms only when the concrete was not indented when pressed with the thumb. They indicated possible variation in drying from 24 hours to several weeks, depending on the weather, the thickness of the wall and the wetness of the mix.

Radford's distinguished between setting and hardening, noted the effect of temperature on setting time and distinguished initial set from final set. It also described techniques which could influence setting time, including varying the wetness of the mix and controlling the ambient temperature by using heated enclosures. If surface finishing was desired, rapid removal of forms was called for.

Hill's comments in 1909 on removing forms were more specific than the earlier ones, perhaps because there were several building failures in the first decade of the century related to premature removal of formwork. He emphasized the importance not only of hardness, but also of structural soundness and advised that forms be removed in sequence to allow inspection for faults before the member was loaded.

Radford's cautioned against early drying of green concrete and described the following techniques:

> Green concrete should not be exposed to the sun until after it has been allowed to set for five or six days. Each day during that period the concrete should be wet down by sprinkling water on it, both in the morning and afternoon. This is done so that the concrete on the outside will not dry out much faster than the concrete in the center of the mass.
>
> Old canvas, sheeting, burlap, etc., placed so as to hang an inch or so away from the face of the concrete, will do very well as a protection. Wet this as well as the concrete. Often the concrete forms can be left in place a week or ten days; this protects the concrete during the setting-up period and the above precautions are then unnecessary (*Radford's*, Vol. 5, p. 169).

The necessity to protect "green" concrete from the effects of frost and the methods of ensuring that protection was debated and researched throughout this period.

Frost was considered harmful to natural cement, but only superficially damaging to good Portland. Three protective techniques were recommended:

- heat the materials to be used, particularly the aggregate
- provide a protective enclosure or covering such as sand or straw
- add a material to the mix to prevent freezing. Unslaked lime was used, the heat of hydration preventing freezing, but more usually salt was used.

The earliest advice on exposure to extremes of temperature was published by Butler in the *Canadian Architect and Builder*, 1895:

> The exposure to extremes of temperature has perhaps more to answer for in the shape of unsatisfactory work than is generally recognized. If exposed to a summer sun immediately after being gauged, naturally a great deal of the necessary moisture is evaporated, leaving the cement without sufficient liquid to complete the crystallization already set up. The result frequently is that the work crumbles and shows signs of failure. On the other hand, exposure to frost acts on the water and by expansion destroys the surrounding concrete. During severe weather, therefore, proper precautions should be taken to protect freshly laid concrete from the effects of frost (Butler, p. 90).

However, Rodger's article in the same periodical in 1901 suggests that the danger of freezing was uncertain. In an attempt to reach a conclusion, he conducted tests on cubes of Atlas Portland cement and Louisville cement, a natural cement. He decided that freezing slowed down the hardening process, but had little long-term effect.

The harmful effects of freezing, however, must have been established some time in the first decade of this century. There were several spectacular building failures attributed to freezing in this period and the construction texts after that time detailed standard methods of protection.

Taylor and Thompson included the following clause in their sample specification:

> **Freezing Weather:** No concrete, except that laid in large masses, or heavy walls having faces whose appearance is of no consequence, shall be exposed to frost until hard and dry. Materials employed in mass concrete in freezing weather shall contain no frost. Surfaces shall be protected from frost. Portions of surface concrete which have frozen shall be removed before laying fresh concrete upon them (Taylor and Thompson, p. 36).

Courtesy of A. Powter

The Results of Freeze-thaw Cycles on Cement

While admitting that most natural cements were ruined by freezing, they still appear to have underestimated the possible damage that freezing could cause to Portland cement mixes:

> The setting and hardening of Portland cement in concrete or mortar is retarded, and the strength at short periods is lowered, by freezing, but the ultimate strength appears to be but slightly, if at all, affected....
>
> ... it is the generally accepted belief, corroborated by tests under the most practical conditions and by the appearance of concrete and mortar in masonry construction, that the ultimate effect of freezing upon Portland cement concrete and mortar is to produce only surface injury (Taylor and Thompson, p. 409).

In cases where freezing was unacceptable, they recommended heating the materials, using coiled steam pipes and providing a thick covering of straw, sand or manure.

They also discussed two other possibilities, namely providing a temporary enclosure and adding salt:

> A dam was constructed at Chaudiere Falls, P.Q. when the temperature was 20° below zero. A house 100 feet long by 24 feet wide was built over a portion of the dam in sections about 10 feet square, bolted together, and heated by sheet-iron stoves about 18 inches in diameter by 24 inches high, burning coke. The concrete was mixed and laid in this house, which, when one portion of the dam was completed, was taken down and erected in another place (Taylor and Thompson, p. 413).
>
> Because of its cheapness salt is most commonly employed to lower the freezing point of water. Other materials, such as glycerine, alcohol and sugar, have been experimentally employed, but these appear to have a tendency to lower the strength of the mortar.
>
> A rule frequently cited in print, which practical tests by the authors have proved to be entirely inadequate, is to require one pound of salt to 18 gallons of water for a temperature of 32° Fahr. and an increase of one ounce for each degree of lower temperature. For 16° Fahr. this corresponds to but slightly more than one percent of the weight of the water, an amount too small to be effective (Taylor and Thompson, pp. 414-15).

Taylor and Thompson suggested typical use of salt to be in the 10 percent to 15 percent range and cited experiments by Gowen and Richardson indicating that salt concentrating below 10 percent did not appear to affect ultimate strength.

Hill recommended the same three approaches to protect against freezing, namely heating the materials, providing with or without artificial heaters and adding salt. They argued that concentrations of sodium chloride should be kept below 10 percent of the weight of the water and recommended a 15 to 20 percent solution of calcium chloride or about two percent by volume of the mortar.

The American Steel and Wire Company in 1908 reiterated the opinions expressed by Thomson and Taylor. They acknowledged the danger to natural cements, but indicated that the only effects in Portland cement mixes was a slower set and possible scaling of the surface.

Radford's in 1909 expressed similar views. It suggested, however, that alternating freeze-thaw cycles were damaging and that bonding was affected. On the question of salts, they were more cautious than their predecessors. They warned about possible damage to reinforcing metals and the danger of concentrations above 10 percent.

The dangers of placing concrete in freezing conditions had apparently not yet reached the contractor. The following comment was made in a 1908 report noting the alarming failures in the new Halifax Cathedral.

> They said, however, that the mortar had not been properly made: either an excessive amount of lime had been added to it, the cement had not been sound or the concrete had been allowed to freeze before setting – or a combination of two or three or all of these causes (Tuck, p. 192).

5.0 APPENDIX

Classification of Cements
(Atlas Steel and Wire Company, 1908)

5.1 CLASSIFICATION OF CEMENTS

From an engineering standpoint, limes and cements may be classified as:

- Portland cement
- natural cement
- pozzolan cement
- hydraulic lime
- common lime.

Typical analyses of each are presented below. The composition of natural cement, even different samples of the same brand, is so extremely variable that their analyses cannot be regarded as characteristics of locality.

5.2 PORTLAND CEMENT

Portland cement is defined by Edwin C. Eckel of the U.S. Geological Survey as follows: "By the term Portland cement is to be understood the material obtained by finely pulverizing clinker produced by burning to semi-fusion an intimate artificial mixture of finely ground calcareous and argillaceous materials, this mixture consisting approximately of 3 parts of lime carbonate to 1 part of silica, alumina and iron oxide."

The definition is often further limited by specifying that the finished product must contain at least 1.7 times as much lime, by weight, as of silica, alumina and iron oxide together.

The only surely distinguishing test of Portland cement is its chemical analysis and its specific gravity. In the field it may often be recognized by its cold bluish grey colour, although the colour of Pozzolan and of some natural cement is so similar that this is by no means a positive indication.

The term *Natural Portland Cement* arose from the discovery in Boulogne-sur-Mer, France, as early as 1846, of a natural rock of suitable composition for Portland cement. A similar discovery in Pennsylvania gave rise to the same term in America, but the manufacturers soon found it necessary to add to the cement rock a small percentage of purer limestone. Since the chemical composition of Portland cement, as defined above, is substantially uniform regardless of the materials from which it is made, in the United States the terms "natural" and "artificial" are meaningless.

5.3 NATURAL CEMENT

Natural cement is "made by calcining natural rock at a heat below incipient fusion and grinding the product to powder." Natural cement contains a larger proportion of clay than hydraulic lime and is consequently more strongly hydraulic. Its composition is extremely variable on account of the difference in the rock used in manufacture.

Natural cements in the United States in numerous instances bear the names of localities where first manufactured. For example, Rosendale cement, a term heard in New York and New England more frequently than natural cement, was originally manufactured in Rosendale, Ulster County, NY. Louisville cement first came from Louisville, Ky. The James River, Milwaukee, Utica and Akron are other natural cements named for localities.

The United States produces a few brands of *Improved Natural Hydraulic Cement*, intermediate in quality between natural and Portland, by mixing inferior Portland cement with natural cement clinker.

In England the best known natural cement is called Roman cement. Occasionally one hears the term Parker's cement, so called from the name of the discoverer in England.

5.4 LE CHATELIER'S CLASSIFICATION OF NATURAL CEMENTS

In France there are several classes of natural cement. H. Le Chatelier classifies 'Natural Cements' as those obtained "by the heating of limestone less rich in lime than the limestone for hydraulic lime." They may be divided into three classes:

- quick-setting cements, such as Vassy and Roman (Ciments à prise rapide, Vassy, romain)
- slow-setting cements (Ciments à prise demi-lente)
- grappiers cement (Ciments de grappiers).

Vassy Cements are obtained by the heating of limestone containing much clay, at a very low temperature, just sufficient to decarbonate the lime. They are characterized by a very rapid set, followed

afterwards by an extremely slow hardening, much slower than that of Portland cements.

They differ from Portland cements by containing a much higher percentage of sulphuric acid, which appears to be one of their essential elements and a much lower percentage of lime.

Slow Setting Cements, by the high temperature of calcination, approach Portland cements, but the natural limestones never possess the homogeneity of artificial mixtures, so that it is impossible to avoid in these cements the presence of a large quantity of free lime. The composition of these products varies from that of the Vassy cements to that of the real Portlands.

Grappiers Cements are obtained by the grinding of particles which have escaped disintegration in the manufacture of hydraulic limes. These grappiers are a mixture of four distinct materials, two of which, completely inert, are unburned limestone and the clinkers formed by contact with the siliceous walls of furnaces and two of which, strongly hydraulic, are unslaked lime and true slow-setting cement.

These grappiers cements are even more apt to contain free lime than the natural cements of slow set which are obtained by the heating of limestone containing much more alumina. Because of their constitution, also, the grappiers cements may vary greatly in composition since they are produced by the grinding of a mixture of grains of cement and various inert materials (Taylor and Thompson, pp. 49-50).

5.5 POZZOLAN OR SLAG CEMENT

Pozzolan cement is the product resulting from mixing and grinding together, in definite proportions, slaked lime and granulated blast furnace slag or natural pozzolanic matter (such as pozzolan, santorin earth or trass obtained from volcanic tufa).

The ancient Roman cements belonged to the class of Pozzolans. They were made by mechanically mixing slaked lime with natural pozzolana formed from the fusion of natural rock found in the volcanic regions of Italy. In Germany, trass, a volcanic product related to Pozzolan, has been used with lime in the manufacture of cements.

Blast furnace slag is essentially an artificial pozzolan, formed by the combustion in a blast furnace and the pozzolan or slag cements of the United States are ground mixtures of granulated blast furnace slag, of special composition and slaked lime.

This term (slag or Pozzolan cement) is applied to cement made by intimately mixing by grinding together granulated blast-furnace slag of a certain quality and slaked lime, without calcination subsequent to the mixing. This is the only cement of the Pozzolan class to be found in our markets (often branded Portland) and as true Portland cement is now made having slag for its hydraulic base, the term "slag cement" should be dropped and the generic term Pozzolan be used in advertisements and specifications for such cements.

Pozzolan cement properly made contains no free or anhydrous lime, does not warp or swell, but is liable to fail from cracking and shrinkage (at the surface only) in dry air.

Mortars and concretes made from Pozzolan approximate in tensile strength similar mixtures of Portland cement, but their resistance to crushing is less, the ratio of crushing to tensile strength being about six to seven to one for Pozzolan and nine to eleven to one for Portland. On account of its extreme fine grinding Pozzolan often gives nearly as great tensile strength in three to one mixtures as neat.

Pozzolan permanently assimilates little water compared with Portland, its lime being already hydrated. It should be used in comparatively dry mixtures well rammed, but while requiring little water for chemical reactions, it requires for permanency in the air constant or continuous moisture.

Pozzolanic material has been suggested by Dr. Michaelis of Germany and R. Feret of France, as a valuable addition to Portland cement designed for use in sea water.

5.6 HYDRAULIC LIME

The hydraulic properties of a lime – its ability to harden under water – are due to the presence of clay or more correctly, to the silica contained in the clay. Hydraulic lime is still used to quite an extent in Europe, especially in France, as a substitute for hydraulic cement. The celebrated lime-of-Teil of France is a hydraulic lime.

Edwin C. Eckel states that theoretically the proper composition for a hydraulic limestone should be calcium carbonate

86.8 percent, silica 13.2 percent. The hydraulic limestones in actual use, however, usually carry a much higher silica percentage, reaching at times to 25 percent, while alumina and iron are commonly present in quantities which may be as high as six percent. The lime content of the limestones commonly used varies from 55 percent to 65 percent.

Although the chemical composition of hydraulic lime is similar to Portland cement, its specific gravity is much lower, lying between 2.5 and 2.8.

In the manufacture of hydraulic lime the limestone of the required composition is burned, generally in continuous kilns and then sufficient water is added to slake the free lime produced so as to form a powder without crushing.

5.7 COMMON LIME

The commercial lime of the United States is "quicklime," which is chiefly calcium oxide (CaO).

The setting of lime mortar is the result of three distinct processes which, however, may all go on more or less simultaneously. First, it dries out and becomes firm. Second, during this operation, the calcic hydrate, which is in solution in the water of which the mortar is made, crystallizes and binds the mass together. Third, as the percentage of water in the mortar is reduced and reaches five percent, carbonic acid begins to be absorbed from the atmosphere. If the mortar contains more than five percent, this absorption does not go on. While the mortar contains as much as 0.7 percent the absorption continues. The resulting carbonate probably unites with the hydrate of lime to form a subcarbonate, which causes the mortar to attain a harder set and this may finally be converted to carbonate. The mere drying out of mortar, our tests have shown, is sufficient to enable it to resist the pressure of masonry, while further hardening furnishes the necessary bond.

6.0 BIBLIOGRAPHY

American Steel and Wire Co. 1908. *Engineer's Handbook of Concrete Reinforcement.* New York.

Baker, I.O. 1890. *A Treatise on Masonry Construction.* 3rd edition. John Wiley & Sons, New York.

Butler, D.B. 1895. "The Abuse of Cement," *Canadian Architect and Builder,* Vol. 8, No. 17 (July), p. 90.

Dobson, E. (CE). 1850. *Foundations and Concrete Work.* John Weale, London.

Draffin, J.O. 1943. "A Brief History of Lime Cement, Concrete, and Reinforced Concrete," *University of Illinois Bulletin,* Vol. 40, No. 45 (June). Reprinted in ACI 1976. *A Selection of Historic American Papers on Concrete 1876-1976.* Detroit.

Faija, H. 1884. *Portland Cement for Users.* Crosby Lockwood & Co., London.

Greenwood, H.F. 1897. "Concrete as Made on the Trent Canal," *Canadian Architect and Builder,* Vol. 10, No. 4 (April), pp. 87-89.

Hill, C.S. 1909. *Concrete Inspection.* Myron C. Clark, New York.

Kidder, F.E. 1896. *Building Construction and Superintendence: Part I Mason's Work.* 7th edition. William T. Comstock, New York.

Price, K.S. "Structural History of the Rideau Canal 1826-1832." Unpublished manuscript.

Radford's Cyclopedia of Construction. 1909. *Cement Construction and Materials,* Vol. 5. Radford, Chicago.

Ransome, E.L. 1894. "Concrete Construction: Its Practical Application," *C.A. & B.,* Vol. 7, No. 12 (Dec), pp. 158-59.

Ritchie, T. 1973. *Concrete in Ottawa: A Guide to Some Examples.* Division of Building Research. NRC, Ottawa.

Roger, W.A. 1901. "The Effect of Freezing on Concrete," *C.A. & B.,* Vol. 14, No. 5 (May), pp. 98-99.

Singer, C., et al. 1965. *A History of Technology, 1850-1900.* Oxford University Press, Oxford.

Taylor, F., and S. Thompson. 1907. *Concrete Plain and Reinforced.* John Wiley and Sons, New York.

Tuck, R.C. 1980. *Gothic Dreams.* Dundurn Press, Toronto. Quoted material reprinted by permission: © 1980 Dundurn Press.

Turner, C.A.P. 1909. "Concrete Steel Construction." Farnham Printing, Minneapolis. Reprinted in ACI 1976. *A Selection of Historic Papers on Concrete 1876 to 1926.* ACI, Detroit.

Vicat, L. J. 1837. *A Practical Treatise on Calcareous Mortars and Cements.* London.

Ward, W.E. 1883. "Beton in Combination with Iron as a Building Material," *Transactions of the American Society of Mechanical Engineers.* Vol. 4 (Nov.), New York. Reprinted in American Concrete Institute. 1976. *A Selection of Historic American Papers on Concrete 1876-1926.* Detroit.

PROFESSIONAL PAPERS OF THE ROYAL ENGINEERS

Alexander, Capt. 1837. "Description of a Concrete Bombproof Erected at Woolwich," *Corp Papers,* Quarto 1, pp. 33-42.

Ardaugh, Lt. J.C. 1866. "Report Upon Concrete Revetments Built at New Haven Fort," *Corp Papers,* New Series 15, pp. 161-68.

Graham, Col. G. 1871. "Transverse Strength of Railway Iron When Used for Purposes of Construction," *Corp Papers,* New Series 1, pp. 71-82.

Maquay, Maj. J.P. 1874. "Notes on Portland Cement Concrete," *Corp Papers,* New Series 22, pp. 137-55.

Scott, Capt. H. 1862. "On Concrete as Substitute for Brick and Stone Masonry in Works of Fortification," *Corp Papers,* New Series 11, pp. 220-31.

__________. n.d. "On the Manufacture of a New Cement," *Corp Papers*, New Series 10, pp. 132-58.

__________. n.d. "An Account of New Cement," *Corp Papers,* New Series 6, pp. 143-48.

Department of Public Works. Specification and addendum for construction of Fox and Barret fireproof floor, 1859 and 1863.

Illustrations are the Property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

4.1
PERIOD MASONRY
ROUGH STONE WORK

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: CLAUDE LEVESQUE

CONTENTS

1.0 INTRODUCTION

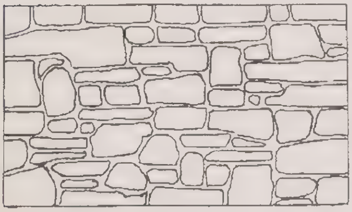
Stone masonry may be classed in various ways, such as by the kind of stone used, surface finish, bonding, etc. In this article, the classification is based on the degree of rectangularity after working. According to the general shape of stones, the masonry may be divided into three classes: rubble masonry, squared masonry and ashlar or cut stone masonry. Only the first two categories will be discussed here. The last one is the subject of another article.

1.1 RUBBLE MASONRY

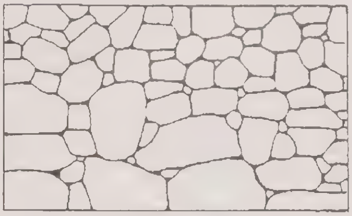
Rubble masonry, also known as unsquared masonry, is composed of unsquared stones as they come from the quarry. The irregularities are filled in with mortar or spalls as the stones are set. The stones may be either quarried or field stones.

The three kinds of rubble masonry are known as uncoursed, random coursed and coursed.

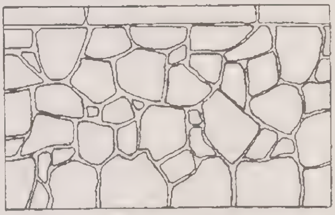
A UNCOURSED



FIELD OR GREEK BOTTOM STONE – NATURAL – WITH MORTAR JOINTS

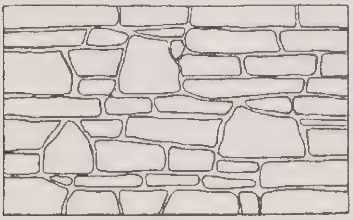


BOULDER WALL – LAID DRY OR WITH MORTAR JOINTS

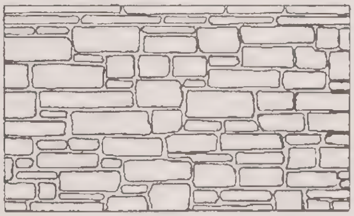


ROUGH STONE – TRIMMED – WITH MORTAR JOINTS

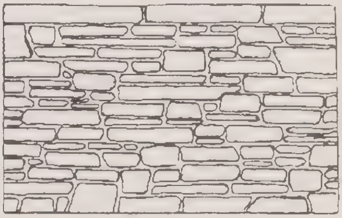
B RANDOM COURSED



FIELD STONE – NATURAL – WITH MORTAR JOINTS

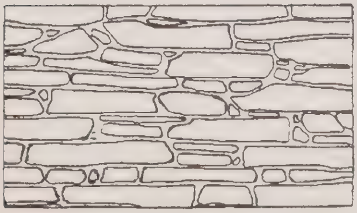


RANDOM RUBBLE WITH MORTAR JOINTS

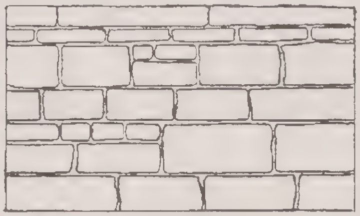


SPLIT STONE WITH MORTAR JOINTS

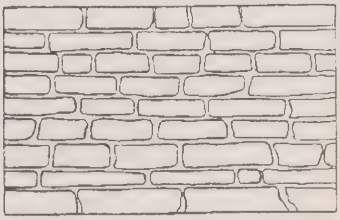
C COURSED



FIELD STONE – NATURAL – COARSE – WITH MORTAR JOINTS



COURSED RANDOM STONE WITH MORTAR JOINTS



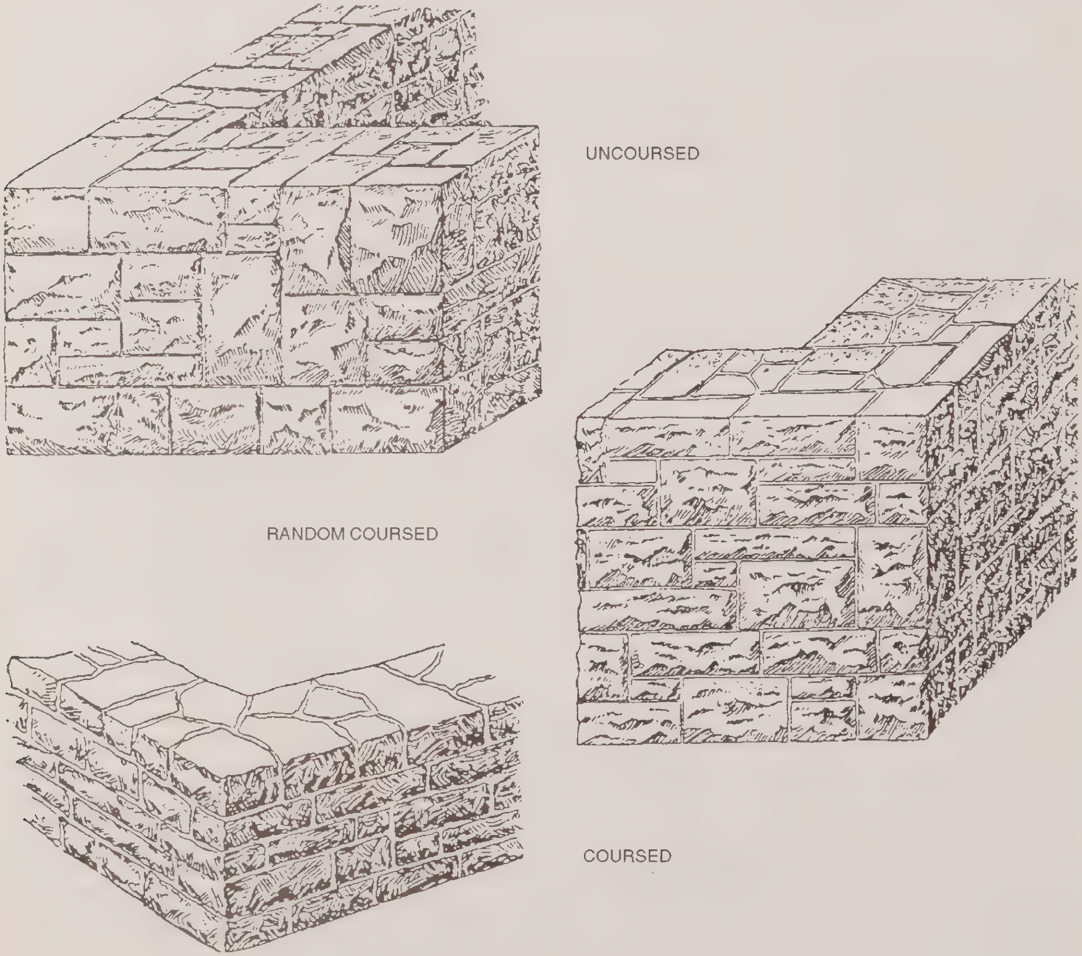
PLAIN RUBBLE IN COURSES WITH MORTAR JOINTS

Different Types of Rubble Masonry Units

1.2 SQUARED STONE MASONRY

Squared stone masonry includes all stones that are roughly squared and dressed on beds and joints. It is distinguished from ashlar by the degree of closeness of the joints. In squared stone masonry, the joints are between one half and one inch thick. Some authors refer to this class of work as block-in-course masonry (Hodgson, p. 225).

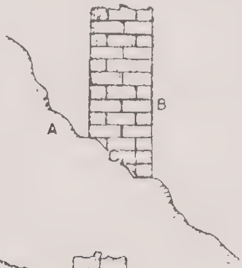
The three kinds of squared stone masonry are known as uncoursed, random coursed and coursed. Ira O. Baker noted on page 137 of *A Treatise on Masonry Construction* (1897) that he preferred the terms random-work, broken range-work and range-work respectively.



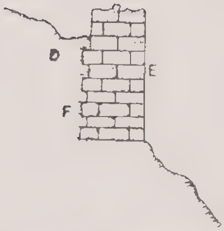
Different Types of Squared Stone Masonry Units: a) uncoursed, b) random coursed, and c) coursed

1.3 FOUNDATIONS

The governing factor when selecting a foundation type is the nature and state of the soil on which the building will be erected. A good reference book illustrating the late 18th-century approach to different kinds of foundation systems used in various soil conditions is *Cours d'architecture ou traité de la décoration, distribution et construction des bâtiments* (Blondel and Matte, pp. 216-54).

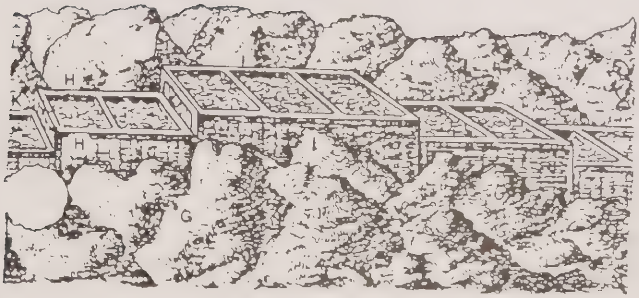


A Rock Profile
B Wall Profile
C Indentations to Permit Embedment of Stones



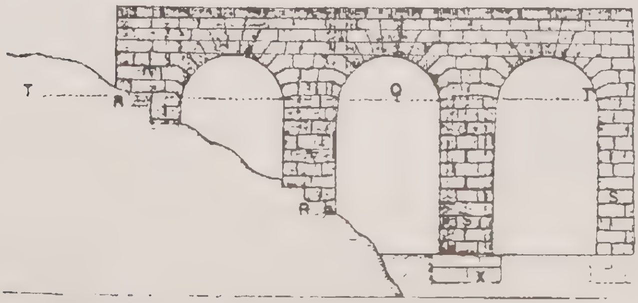
ON A SHEER CLIFF PART OF THE WALL BEING EMBEDDED IN THE ROCK

D Rock Profile
E Wall Profile
F Vertical Indentations to Permit Embedment of Stones



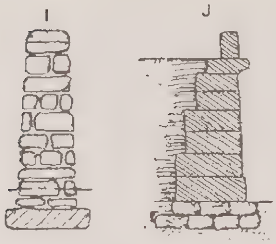
CONSOLIDATED RUBBLE FOUNDATION BUILT ON A VERY UNEVEN SURFACE

G Rock
H & I Wooden Formwork
K Profile of Formwork



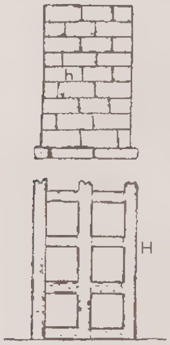
ARCADES BEING USED WHERE GREAT DEPTH IS REQUIRED

[illegible]
[illegible]
[illegible]
T [illegible] on Line to Indicate [illegible] Mortar in the Piers
[illegible] Compacted



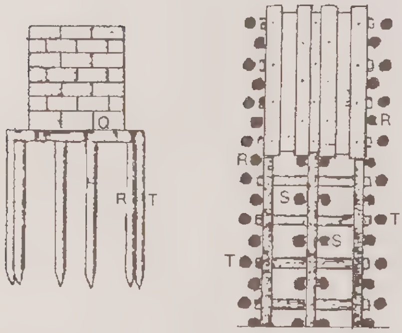
ORDINARY FOUNDATIONS USED ON FIRM SOILS

I With a Large Stone Footing as Bottom Course
J. With Several Layers of Rubble Masonry



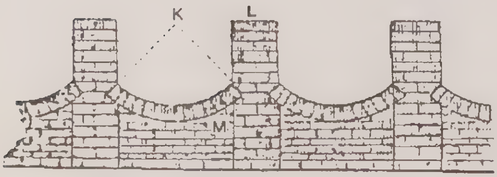
CRIBWORK USED AS SPREAD FOOTING WHEN BUILDING FOUNDATIONS ON SOFT SOILS

H Cribwork
h. Masonry



SUPPORTING CRIBWORK ON PILES

Q. Cribwork
R S T. Piles



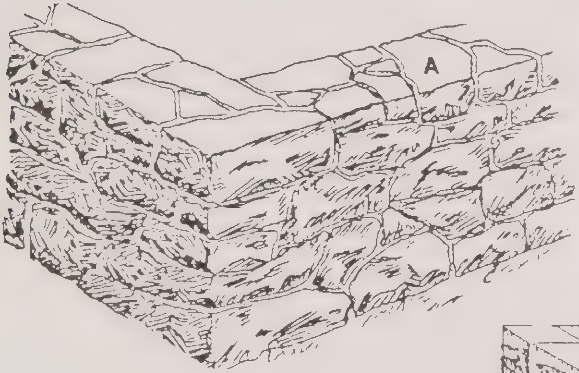
INVERTED ARCH FOUNDATIONS USED TO SPREAD COLUMN LOAD EVENLY ON FIRM OR SOFT SOILS

K. Center of Arch
L Column
M Inverted Arch

OTHER TYPES OF FOUNDATIONS

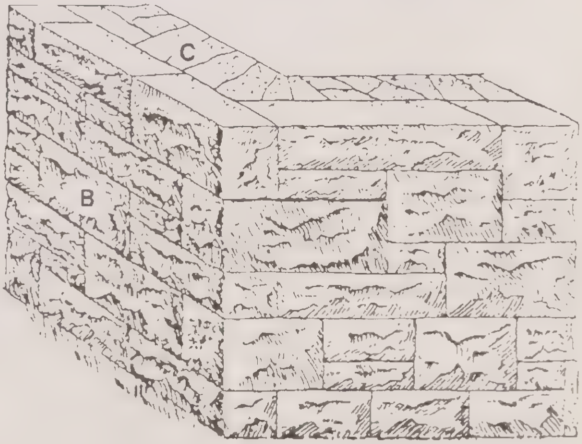
1.4 TYPES OF WALLING

The common types of stone walling are cavity-filled, solid wall, backed wall and faced wall. The oldest was cavity-filled which meant a rubble filling was either consolidated with lime mortar or laid dry (Blondel and Matte, pp. 255-57). The three latter types are those that are most often encountered. The solid wall was built out of rubble or squared stone masonry. Rubble was more economical, but because of its appearance, it was sometimes faced with cobble stone or parging. The squared stone masonry was more expensive and was backed with rubble or brick. Solid squared stone masonry was only used where strength was needed. Not as frequently encountered is the hollow wall, which generally had an outer skin of stone and an inner skin of brick.



RANDOM COURSED RUBBLE (SOLID STONE)

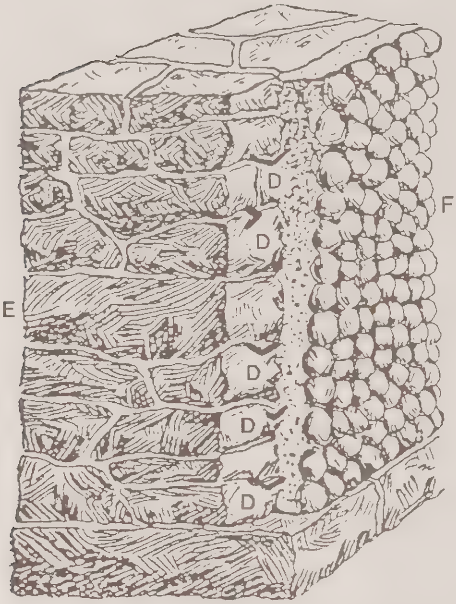
A Bond Stone



RANDOM COURSED SQUARED STONE MASONRY WITH RUBBLE BACKING

B Squared Stone Masonry
C Rubble Backing

DIFFERENT TYPES OF STONE WALLING

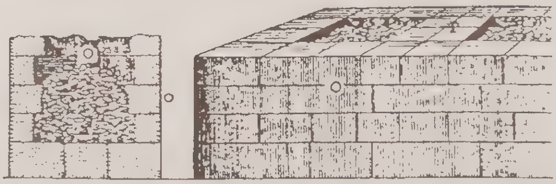


RANDOM COURSED RUBBLE WITH COBBLE STONE FACING

D Anchors
E Rubble Masonry
F Cobble Stone Facing

RUBBLE WALL WITH FILLED CAVITY

G Rubble Facing
H Horizontal Brick Bonding



COURSED SQUARED STONE WALL WITH RUBBLE FILLED INTERIOR COFFERS

O Squared Stone Masonry
P Vertical Bonding
Q Rubble Filled Coffers

HOLLOW WALL WITH STONE FACING AND BRICK BACKING

R Stone Skin
S Brick Skin
T Hollow Wall Anchors

DIFFERENT TYPES OF STONE WALLING (CONT'D)

1.5 COLUMNS AND BUTTRESSES

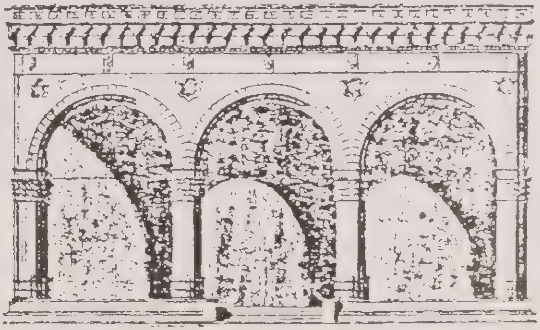
The terms "columns" and "buttresses" are nowadays used to identify an array of elements that once had their own definitions. A column today is understood to be an element which supports another in a vertical direction; a buttress is defined as a projection from a wall which creates additional strength and support. However, during the periods of Classical and Gothic Revival, different types of columns and buttresses were in use and each had their own definition, depending on their nature or function. This subsection precisely defines and illustrates the different types of columns and buttresses. The definitions have been extracted from *An Encyclopedia of Architecture* and *A Concise Glossary of Terms Used in Grecian, Roman, Italian and Gothic Architecture* (Gwilt, pp.1231, 1281, 1338; Parker, pp. 48, 198).

Column: A body, usually cylindrical in shape, which supports another in a vertical direction.

Pier: A solid between the doors, windows and other openings of a building. The support of a bridge on which the arches rest. This name was incorrectly given to pillars in Norman and sometimes in Gothic architecture.

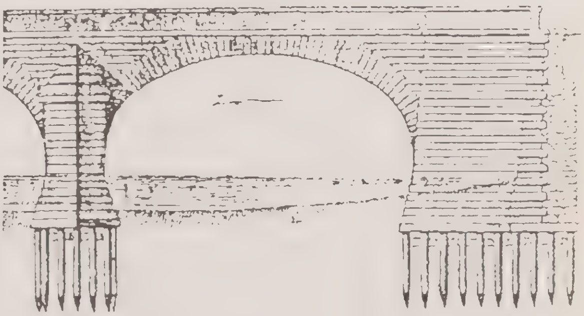
Pillar: A column of irregular form always disengaged and always deviating from proportions of the orders.

Pilaster: A sort of square column or pillar, used in Classical architecture, sometimes disengaged but generally attached to a wall from which it projects a third, fourth, fifth or sixth of its breadth.



A TYPICAL PIER BETWEEN ARCHED OPENINGS

TYPICAL PILLAR



BRIDGE PIER

Buttress: A mass of masonry which supports the side of a wall of great height, or which is pressed on the other side by a bank of earth or body of water. Buttresses are employed against the piers of Gothic buildings to resist the thrust of vaulting.

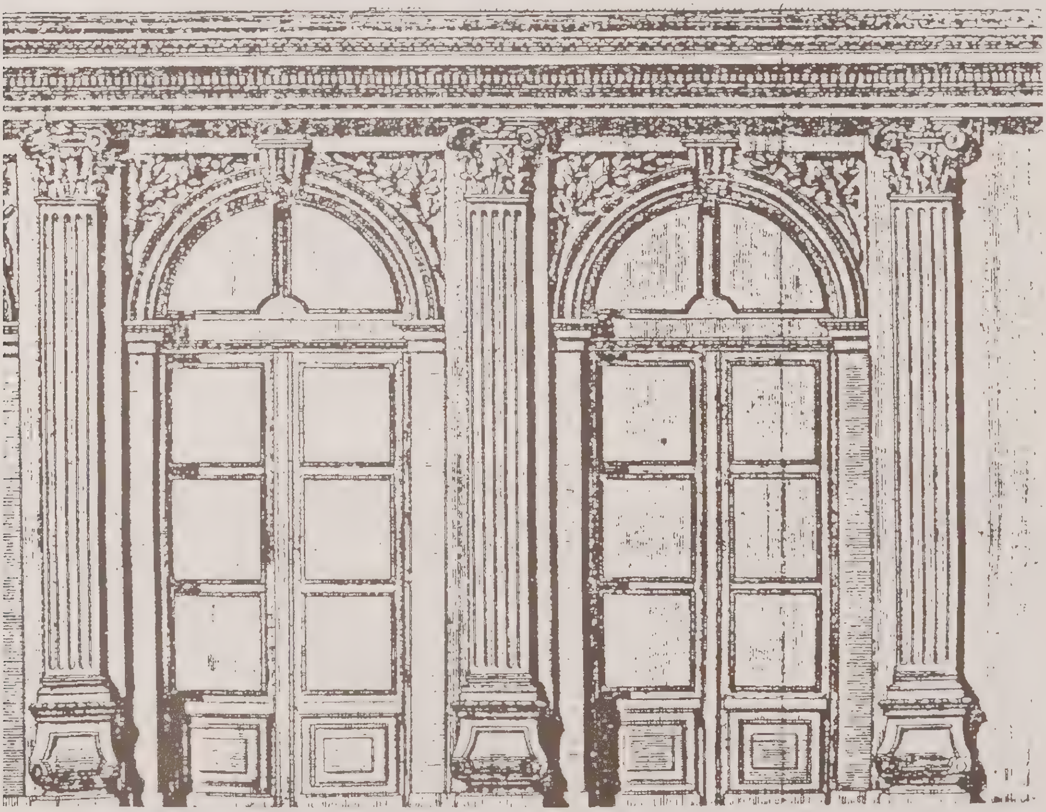
Flying Buttress: A buttress in the form of an arch, springing from a solid mass of masonry and abutting against the springing of another arch which rises from the upper point of the first. Formed by the vertical planes attached.*

Pillared Buttress: Attached to the walls themselves, they sometimes form the upright terminations of flying buttresses.

* The meaning of "vertical planes," as implied by the definition, is a pillar on the inside and a buttress on the outside, which lie in the same vertical plane and are each attached to the wall.

1.6 DIFFERENT TYPES OF JOINTING

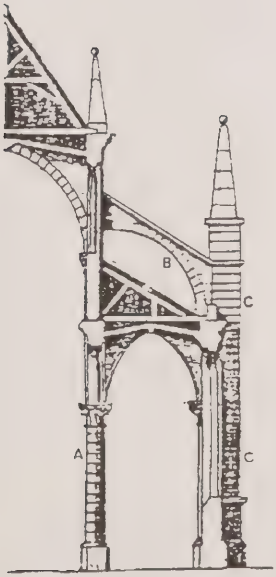
The irregular pattern and thickness of joints in rubble and squared stone masonry called for varied treatment with the trowel. With irregular projecting stones, a flat surface of mortar was frequently used. Occasionally, pebbles were pushed into the mortar before it set, giving a decorative effect known



TYPICAL PILASTERS

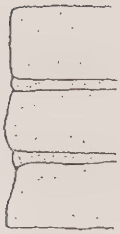
CORNER BUTTRESS WITHOUT DIMINUTION

A BUTTRESS WITH DIMINUTION

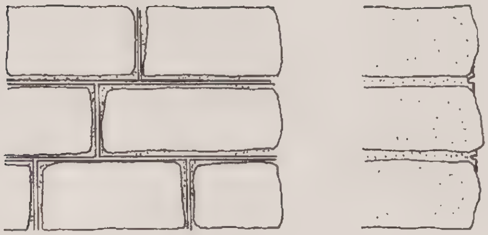


FLYING AND PILLARED BUTTRESSES

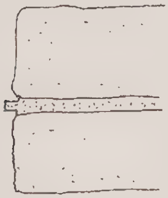
A Column
B Flying Buttress
C Pillared Buttress



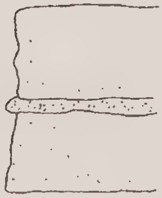
A. FLAT JOINT



B. FLAT JOINT JOINTED

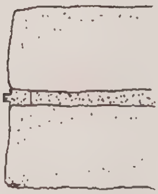


A FLAT RAISED



B. V–SHAPED

C TUCK POINTING



D. BASTARD TUCK POINTING

as galleting. The flat joint could also be tooled in order to create a joint regularity effect.

The mortar joints could also be raised in several fashions such as flat raised, V-shaped, tuck and bastard tuck pointing. Pointing consisted of filling recessed joints with cement or some hard-setting mortar. Generally, the raised joints were used to increase the effect of forming sharply defined joints. The mason would sometimes create new joints to make the work appear to be ashlar.

1.7 QUOINS AND DRESSINGS TO DOORS AND WINDOWS

In rubble and squared stone masonry walls, quoins were built with more carefully fashioned blocks of stone in order to give strength to the wall. These were sometimes worked to give a pleasing effect or, at times, were merely left as a rough or quarry face, with only the four face edges dressed squarely. Quoins were also done in brick, but were usually encountered only in flint stone walls where brick lacing bands were required to help bind the walls together. The above comments also apply to dressings for door and window jambs.

Sills and lintels were usually made of stone, but occasionally were made of wood or brick. Stone lintels were composed of ashlar blocks forming a flat arch, or were one length, usually surmounted by arches in the case of wide openings.

1.8 COPING STONES AND CORNICES

Coping stone, the highest and covering course of masonry, formed a waterproof top which preserved the interior of walls that would otherwise burst in frosty weather.

Cornices, moulded courses of masonry crowning buildings, generally had a large projection to throw off rain. When a cornice had a large projection, it was surmounted by a blocking-course to counteract the overturning.

2.0 PERIOD FIELD PRACTICE

Period literature on the field techniques of stone masonry is scarce. Two possible reasons for this are: the use of an apprenticeship system relying on oral tradition and an emphasis on professional secrecy to protect against competition and illicit intruders. These customs emerged during the Middle Ages when the stonemasons' guild system peaked and many customs were still observed by the North American stoneworkers (Brooks, pp. 6-9).

2.1 MEASUREMENT OF STONE

General rules for estimating the quantity of stone in the work to be erected, were outlined in the *New Building Estimators' Handbook* by William Arthur:

> Quantity. Allow 2,900 lbs of stone to the cu yd of masonry in the wall. The owner of a quarry writes me that his railroad customers say that it takes from 3,000 to 3,200 lbs. A practical mason gives the same figure. Something depends upon the stone. Thin stone with more joints make up in mortar for less weight required. On small stones about one-third of the mass will be mortar; large stones one-fifth to one-fourth. The C. & N.W.R.R. finds 2,700 lbs enough for a yd in the wall, but the stone is of good quality. The ordinary Chicago allowance is 13,000 lbs to 128 cu ft, or 2,742 lbs to the cu yd of finished wall (Arthur, p. 185).

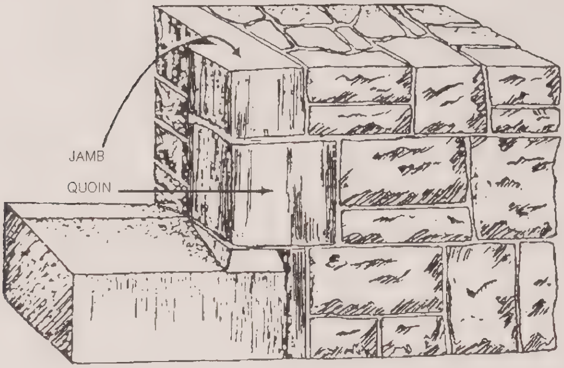
When ordering from the quarry, dressing waste had to be considered. The same author gave additional rules to that effect:

> For ordinary work allow 6 at the quarry to 5 in the wall. The proportion of 128 in the quarry to 100 in the wall is often used and on 400 to 500 cu yds was tested with satisfactory results. In case stone is not brought by weight this will serve as a measure of quantities. 1 cu yd of stone when broken occupies 1.9 cu yd when perfectly loose, or 1.75 when piled up (Arthur, p. 186).

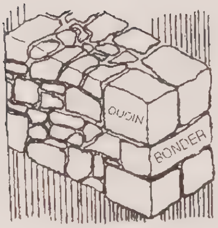
2.2 MEASUREMENT OF MORTAR

General rules for measuring the amount of required mortar were given by Baker:

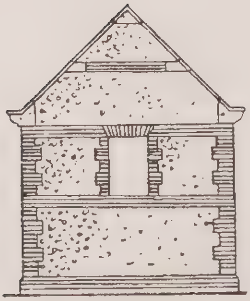
> The amount of mortar required for squared-stone masonry varies with the size of the stones and with the quality of the masonry; as a rough average, one sixth to one quarter of the mass is mortar.... When laid in 1 to 2 mortar*, squared-stone masonry will require 1/2 to 3/4 of a barrel of cement per cubic



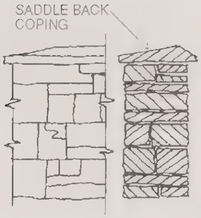
QUOIN AND JAMB DONE IN ASHLAR IN A SQUARED STONE MASONRY WALL



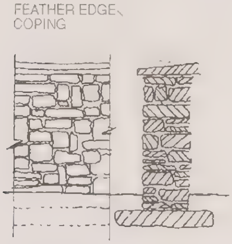
SQUARED STONE QUOIN IN A RUBBLE WALL



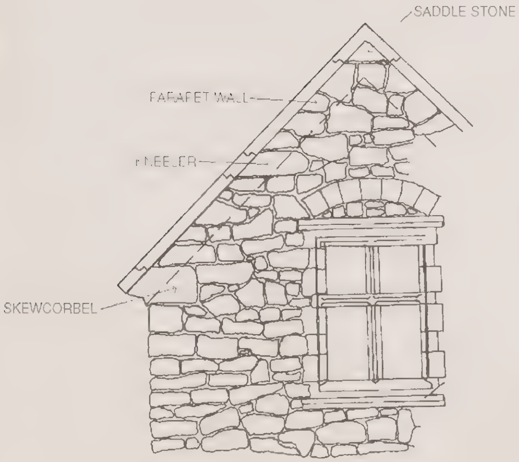
QUOINS, DRESSINGS AND LACING BANDS DONE IN BRICK IN A FLINT RUBBLE WALL



A. SADDLE BACK COPING



B. FEATHER EDGE COPING



C. DIFFERENT TYPES OF
COPING STONES USED ON
PARAPET WALL

Different Types of Coping Stones

> yard of masonry.... If rubble masonry is composed of small and irregular stones, about one third of the mass will consist of mortar; if the stones are larger and more regular, one fifth to one quarter will be mortar. Laid in 1 to 2 mortar, ordinary rubble requires from one half to one barrel of cement per cubic yard of masonry (Baker, pp. 144, 146-47).
>
> [* Means, one part cement to two parts sand.]

2.3 SELECTING MATERIALS

The master mason, when selecting stones for the construction of a building, usually considered the cost. The factors which contributed to the cheapness of stone were abundance, proximity of quarries to place of use, facility of transportation and the ease with which it was quarried and worked. According to Knoop and Jones, writing on medieval masonry, if the project was large, the employers would own or lease quarries and perhaps send masons to the quarry to dress up the stones there in order to save on transportation costs (Knoop and Jones. p. 68). For smaller projects, the stones were bought from a nearby quarry or, depending on the economics, were dressed at the quarry or site. Other factors the master mason considered were the durability, strength and beauty of stones, but to a much lesser extent than cost, especially for rough stone work. For lower classes of work such as rubble walls, field stones or remains of the quarry scrap pile were used. William Arthur wrote:

> Good work requires what is colloquially known as "two-man rubble, – that is, stone too heavy for one man to lift– "one-man rubble" is fit only for cheap work. It would not be accepted on government buildings (Arthur, p. 185).

In order to avoid deterioration due to freezing and thawing, harder stones were used for the foundations. However, the master mason would not have allowed the use of stone that could absorb a significant amount of water. He also refused stones that had not seasoned (i.e. lost their quarry water, especially sandstone and limestone).

In choosing the mortar type, the mason tried to match it to the density and absorbency of the stones used in the work. Soft mortars were the best choice for soft stones, while hard mortars were best for hard stones. The choice of mortar would also depend on the class of work performed. The rougher the beds and joints, the better the mortar would be because its primary function was to equalize pressures. In a fieldstone wall, for example, a strong cement mortar was chosen.

2.4 STORING

There is no particular care required in handling rubble stones because there are no edges or corners that must be protected from injury. Squared stones that have been dressed at the quarry need more careful handling and should be stored properly on site. According to William S. Lowndes in his book *Building Stone Foundations - Masonry*:

> If the stones are to be placed on the ground adjacent to the building, they should have strips of wood placed beneath them so that they will not come into actual contact with the soil, as certain kinds of stone will become stained if they rest directly upon the soil. If they are not placed inside the building they should be carefully covered over with boards until needed in the building (Lowndes, p. 55).

2.5 ESTIMATING

The quarrying and dressing costs could vary greatly and usually accounted for a significant percentage of the total job cost. Thus it was important to evaluate those costs as precisely as possible. Baker gave general rules to that effect:

> **Quarrying.** After the preliminary expenses of purchasing the site of a good quarry, cleaning off the surface earth and disintegrated top rock, and providing the necessary tools, trucks, cranes, etc., the total net expenses for *getting out* the rough stone for masonry ready for delivery may be roughly estimated thus: Stones of such size as two men can readily lift, measured in piles, will cost per cubic yard from $^1/_4$ to $^1/_2$ the daily wages of a quarry laborer. Large stones, ranging from $^1/_2$ to 1 cubic yard each, got out by blasting, from 1 to 2 daily wages per cubic yard. Larger stones, ranging from 1 to 1 $^1/_2$ cubic yards each, in which most of the work must be done by wedges in order that the individual stones shall come out in tolerably regular shape and conform to stipulated dimensions, from 2 to 4 daily wages per cubic yard. The lower prices are low for sandstone, while the higher ones are high for granite. Under ordinary circumstances, about 1 $^1/_3$ cubic yards of good sandstone can be quarried at the same costs as 1 of granite

– or, in other words, calling the cost of granite 1, that of sandstone will be 3/4; hence the means of the foregoing limits may be regarded as rather full prices for sandstone, rather scant for granite, and about fair for limestone or marble.

Dressing. In the first place, a liberal allowance should be made for waste. Even when the stone wedges out handsomely on all sides in large blocks of nearly the required shape and size, from 1/6 to 1/4 of the rough block will generally not more than cover waste of dressing. In moderate-sized blocks (say averaging about 1/2 a cubic yard each) got out by blasting, from 1/4 to 1/3 will not be too much for stone of medium character as to straight splitting. The last allowance is about right for well-scabbled dressing. The smaller the stones the greater must be the allowance for waste. In large operations it becomes expedient to have the stones dressed, as far as possible, at the quarry, in order to diminish the cost of transportation, which, when the distance is great, constitutes an important item – especially when by land and on common roads (Baker, pp. 153-54).

The following estimate of the cost of rubble masonry was taken from Trautwine's *Engineer's Pocket Book* as cited by Baker. The estimate is based on the assumption that a mason receives $3.50 and a labourer, $2.00 per day of eight hours:

Rubble. With stones averaging about .5 cubic yards each and common labour at $1 per day, the cost of *granite rubble*, such as is generally used as backing for the foregoing ashlar, will be about as follows:

Getting the stone from the quarry by blasting, allowing 1/8 for waste in scabbling, 1 1/7 cu. yds @ $3.00, ... 3.43

Hauling 1 mile, loading and unloading, ... 1.20

Mortar (2 cu. ft. or, 1.6 struck bushels of quicklime and 10 cu. ft. or, 8 struck bushels of sand or gravel and mixing), ... 1.50

Scabbling, laying, scaffolding, hoisting machinery, etc., ... 2.50

Net cost, ... $8.63

Profit to contractor, say 15 per cent, ... 1.30

Total cost per cubic yard, ... $9.93

Common rubble of small stones, the average size being such as two men can handle, costs to get it out of the quarry about 80 cts. per yard of pile, or, to allow for waste, say $1.00. Hauling 1 mile, $1.00. It can be roughly scabbled and laid for $1.20 more. Mortar, as above, $1.50. Total net cost, $4.70; or with 15 per cent, profit, $5.40, at the above wages for labor (Baker, p. 155).

2.6 PREPARATION

Prior to the actual laying of stones, some preparation was needed in dressing up the stone (if not already done at the quarry) and mixing the mortar. The stones for rubble masonry were used as they came from the quarry, without preparation other than the removal of very acute angles and excessive projections from the general figure. In the case of squared stone masonry, the stones were roughly squared and roughly dressed on beds and joints. According to Baker:

The dressing is usually done with the face hammer or ax, or in soft stones with the tooth hammer. In gneiss it may sometimes be necessary to use the point.... Where the dressing on the joints is such that the distance between the general planes of the surfaces of adjoining stones is one half inch or more, the stones properly belong to this class.

Three subdivisions of this class may be made, depending on the character of the face of the stones:

(a) **Quarry-faced** stones are those whose faces are left untouched as they come from the quarry.
(b) **Pitch-faced** stones are those on which the arris is clearly defined by a line beyond which the rock is cut away by the pitching chisel, so as to give edges that are approximately true.
(c) **Drafted Stones** are those on which the face is surrounded by a chisel draft, the space inside the draft being left rough. Ordinarily, however, this is done only on stones in which the cutting of the joints is such as to exclude them from this class.

In ordering stones of this class the specifications should always state the width of the bed and end joints which are expected, and also how far the surface of the face may project beyond the plane of the edge. In practice,

> the projection varies between 1 inch and 6 inches. It should also be specified whether or not the faces are to be drafted (Baker, p. 132).

As mentioned, the other task the mason had to accomplish prior to the laying was the preparation of the mortar. After he had chosen the proper mix and proportions, he slaked the lime, when lime was chosen over cement as binder. He also had to screen and clean the sand. The mason finally mixed the lime, sand and water in the right proportions. For more information concerning the preparation of mortar, please refer to Section 5.1 "Period Bricklaying and Tiling: Brickwork" and Volume VI.3.1 "Mortar Composition and Properties."

3.0 HANDLING MATERIALS

3.1 AT THE QUARRY

Handling large stones, which weigh from 140 to 180 pounds per cubic foot (64 to 81 kg per cu m), is difficult. According to Harley J. McKee in *Introduction to Early American Masonry*:

> The great masses of stone split off in the quarry were usually subdivided on the spot, to the approximate size needed for building. If the subdivided pieces were too heavy to be turned or lifted by a few men, levers were used to manipulate the material onto a sledge, stone boat or cart. The sledges and carts carried the material along a ramp to the surface. Large stones were sometimes moved on wooden rollers. Cranes, consisting of booms and vertical masts held by stays, could handle fairly heavy loads with the mechanical advantage afforded by windlass and compound pulleys. They could easily be taken down and moved. When steam engines became available to provide power, heavy loads were lifted more rapidly; in the late 19th century, steam-powered hoists were common in American quarries. By that time, deep quarries were often equipped with strong cables stretched between towers, along which carriages were moved, carrying hoisting tackle. The tackle was supplied with power from a stationary engine in a shed at the rim of the quarry. (McKee, p. 18).

3.2 TRANSPORTATION

In view of the high cost of transport, it is assumed that those responsible for building operations gave the problem of carriage very careful consideration. Jones and Knoop mentioned that in some cases in medieval times, those responsible organized transport departments of their own; in other cases they hired men with carts and teams, or sailors with ships.

Usually carters with vehicles and teams were hired as required and paid by the trip or by the day (Jones and Knoop, p. 46). A few of the carts could be hired from the masons employed on the building operations, but the majority were probably obtained by scouring the surrounding country.

In a cold climate, winter transportation offered many advantages, as McKee reported:

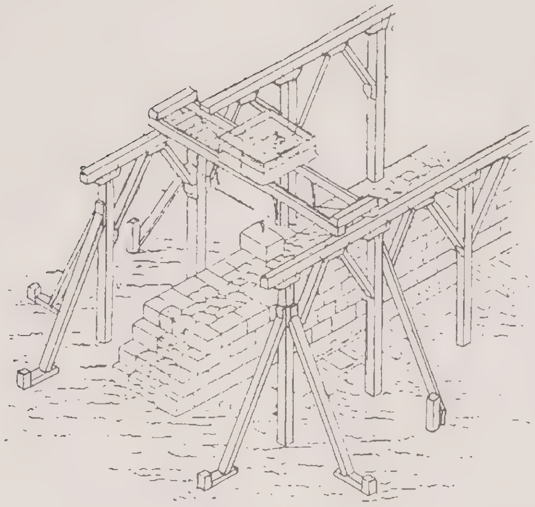
> For the construction of the Erie Canal, beginning in 1817, stone was transported on sleds during the winter. This was especially advantageous in some of the marshy country through which the canal passed. There, a heavy load could not be supported unless the ground was frozen. A report of the canal commissioners dated January 25, 1819, expressed the hope that there would be five weeks of good sleighing that winter.
>
> In New England, heavy stones were transported overland by oxen. Winter was the best season for doing this because the animals were not needed for farm work then (McKee, p. 19).

3.3 AT THE SITE

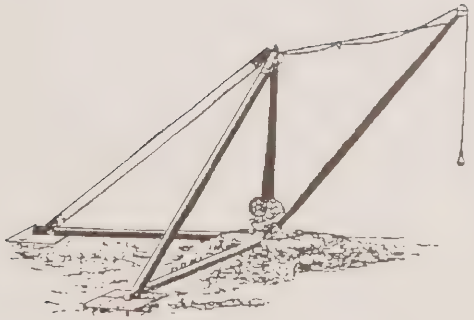
Stones too heavy to be lifted into position by hand were hoisted by different methods. Some were pulled by hand up ramps supported by scaffolding; others were so large and heavy that they required horse-drawn carts. For stones even larger and heavier, the scaffolds, generally made of poles lashed with cords, were not safe, therefore other hoisting structures were used. The gantry could be used for linear walls and a derrick crane when building large houses and other structures. The Lewis, a device used since 500 B.C. in Greece, was commonly used to attach the hoisting ropes to a piece of stone. The Lewis was an iron tenon, made in sections, which fit into a dovetail mortise in the top of the stone. These were easily removed section by section when the stone was in place.

3.4 STONE LAYING PROCEDURE

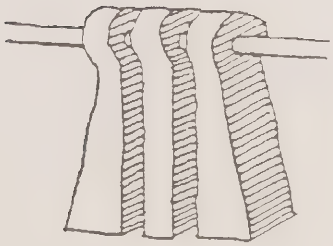
The following information on stone laying briefly describes the techniques of laying a rubble stone wall. General rules for



THE GANTRY



THE DERRICK



THE LEWIS DEVICE

stone setting are compiled at the end of this section, in the hope that they may be useful when building either a rubble or a squared stone masonry wall.

Baker described in 1897 the laying of a rubble stone wall:

> The stones used for rubble masonry should be prepared by simply knocking off all the weak angles of the block. It should be cleansed from dust, etc., and moistened, before being placed on its bed. This bed is prepared by spreading over the top of the lower course an ample quantity of good, ordinary-tempered mortar in which the stone is firmly embedded. The vertical joints should be carefully filled with mortar. The interstices between the larger masses of stone are filled by thrusting small fragments or chippings of stone into the mortar. In heavy walls of rubble masonry, the precaution should be observed to give the stones the same position in the masonry that they had in the quarry, i.e., to lay them on their "natural bed," since stone offers more resistance to pressure in a direction perpendicular to the quarry-bed than in any other. The directions of the laminae in stratified stones show the position of the quarry-bed.
>
> To connect the parts well together and to strengthen the weak points, *throughs* or binders should be used in all the courses, and the angles should be constructed of cut or hammered stone (Baker, p. 145).

In setting or putting together the stones to form a structure, the following principles gathered from Lowndes in 1906 should be observed:

1. The vertical joints in any course should not come directly over the vertical joints in the course below.
2. Where the thickness of a wall is made up of two or more pieces of stone, bond stones or blocks that run through from face to face of the wall should be used whenever possible, for the purpose of binding the whole mass together.
3. Where the width of the wall is so great that a long bond stone would be liable to break, headers should be used at frequent intervals, should be placed as nearly over the center of the stretchers as possible and should extend two-thirds across the wall, alternately from opposite faces.
4. When stratified stones are used, they should be laid on the natural bed; that is, the bed on which they rested in the quarry. Stratified stones when placed vertically are split and scaled by the action of the weather; moreover, a stone in this position has not as much strength to resist crushing as it has when placed with the lamina horizontal. Stones placed with their strata vertical can sustain only six-sevenths of the load borne by similar stones placed on the natural bed. When a stratified stone is used in a cornice with overhanging moldings, however, the natural bed should be placed parallel to the side joints; for, if placed horizontally, layers of the overhanging portions will be liable to drop off. (Precise directions for ascertaining the natural bed of a stone cannot be given. With some stones it is easy to distinguish; with others, it is a matter of extreme difficulty; in case of doubt, the quarry owners should be consulted).
5. Every joint or space between the stone should be filled with mortar and the spaces should be as small as possible.
6. The surfaces of porous stones should be moistened with water before being placed in contact with the mortar; otherwise they will absorb the moisture from the mortar, causing the mortar to become a crumbling mass.
7. For the sake of appearance, the largest stones should be placed in the lower courses, the thickness of the courses gradually decreasing toward the top.
8. The rougher the beds and joints, the better the mortar should be. The principal office of the mortar is to equalize the pressure and the more nearly the stones are dressed to closely fitting surfaces, the less important the quality of the mortar; with rough beds, the best quality of mortar should be used. This rule is frequently incorrectly reversed; that is, with fine, smooth, dressed beds the best quality of mortar is used. When using stones that have been sawed, it may be necessary to roughen the surface of beds and joints with the point or tooth ax, so that the mortar will adhere.
9. Porous stones should not be placed at or below the ground line.
10. In foundations, absorption of moisture from below should be prevented by placing a course of

material that water will not penetrate at or near the surface of the ground.

11. In setting cut stones, as sills, water-tables, belts, etc., the mortar should be kept back about 1 inch from the face, the space being filled when the pointing is done.
12. If a stone that has once been set requires to be moved for any reason, it should be lifted clear from the mortar bed, the mortar removed and the stone set in a new bed of mortar in the new position.
13. Hammering or cutting stones on the top of stones just set in the work should not be practiced (Lowndes, pp. 56-58).

3.5 POINTING AND REPOINTING

When laying any type of masonry, whether with common or hydraulic mortar, the exposed edges of the joints will naturally lack density and hardness. The mortar in the joints near the surface is especially subject to dislodgement, since the contraction and expansion of the masonry is liable either to separate the stone from the masonry or to crack the mortar in the joint. This permits rainwater to enter, which, after freezing, forces the mortar from the joints. Therefore it was usual, after the masonry was laid, to refill the joints as compactly as possible, to the depth of at least half an inch, with mortar prepared especially for this purpose. This operation is called pointing.

It is best to point with mortar having the same density and absorbency as the stones in the wall. Soft stones should be pointed with soft mortar; hard cement mortar will cause the softer material to disintegrate.

The technique of pointing was described in some detail by Baker:

> The mortar, when ready for use, should be rather incoherent and quite deficient in plasticity. Before applying the pointing, the joint should be well cleansed by scraping and brushing out the loose matter and then be well moistened. Of course, the cleansing out of the joints can be most easily done while the mortar is new and soft. The depth to which the mortar shall be dug out is not often specified; it is usually cleaned out about half an inch deep, but should be at least an inch. In the Brooklyn bridge piers the joints were cleared 1 1/2 inches deep.
>
> The mortar is applied with a mason's trowel and the joint well calked with a calking iron and hammer. In the very best work, the joint is also rubbed smooth with a steel polishing tool. Walls should not be allowed to dry too rapidly after pointing; therefore, pointing in hot weather should be avoided (Baker, p. 141).

Repointing is the operation of removing old fragmented mortar in order to point again. It basically followed the same procedure described above for pointing. Care must be taken not to enlarge the width of the joints when raking out the old mortar.

3.6 PROTECTION OF WORK

Two references relating to protection of work are found in W.S. Lowndes and F.T. Hodgson. The first dealt with protection against physical damage during construction and the second detailed protection against the action of natural elements:

> All courses that project beyond the general lines of the wall, as sills, lintels, belt-courses, etc. should be covered with boards or otherwise protected from damage (Lowndes, p. 58).
>
> • • • •
>
> Provide for covering the tops of walls with asphalted felt if they should be uncovered during the frost or very wet weather (Hodgson, p. 286).

3.7 CLEANING OF STONEWORK

The stone setter, anxious to leave a clean looking building, often suggested that it be washed down with muriatic acid. According to Graham and Emery:

> This should never be permitted. The acid may take out some of the stains for the moment, but it burns the surface and eventually will discolor even those portions that escaped the original staining (Graham and Emery, p. 979).

Graham also discouraged the use of wire brushes for cleaning stonework:

> There was a time when scrubbing with wire brushes was permitted, but this has generally been discarded, since its bad effects have been recognized. It is impossible to use wire brushes without leaving a coating of iron on the surface of the stone and this is bound to leave a worse stain than it corrects....

> The very best treatment of stone to remove smoke, soot, dirt, mortar, etc., is a simple washing. (Graham).

For more information concerning cleaning of stonework, please refer to Vol. IV.4.1 "Stabilization Masonry Structures: Cleaning."

4.0 GENERAL SPECIFICATION CLAUSES

The intent of this subsection is to outline the general specification clauses used in rough stone work. The clauses have been extracted from two sources: Joseph Gwilt, *An Encyclopedia of Architecture, Historical, Theoretical and Practical* and Fred T. Hodgson, *20th Century Bricklayer's and Mason's Assistant.*

The first group of excerpts shown below is taken from J. Gwilt:

> The **stone** to be used in a building generally depends of course on the place where it is to be built, unless, without regard to expense, the employer determines on the use of any particular sort.... In London, Portland stone is most used. Granite or other hard stone is used where great strains and pressures occur, or where use and wear and the action of the weather, indicate its employment.
>
> Having described the sort of stone selected to be of the best quality, free from all vents, shakes, &c., the next direction is, that it shall be throughout laid in the direction of its natural bed in the quarry; and if the whole building is of stone, many of the following particulars will be unnecessary. Where the building is only faced with stone, then the ... fronts (describing them) are to be faced with Portland (or other) stone, ashlaring in courses to fall in with the courses of brickwork; the stretchers of such ashlaring being 4 $^{1}/_{2}$ inches deep and the headers 9 inches, with bond stones running through the whole thickness of the wall in the proportion of $^{1}/_{16}$ of the face, to be introduced where the piers allow. No quoins to show a thickness of less than 12 inches. The whole to be cramped with gunmetal cramps, the mason finding the same and properly running them with lead.
>
> Where the building is of **brick with stone dressings**, then – to provide and set a Portland stone (or other stone or granite) plinth all round (or part, as the case may be) the building, ... feet ... inches high and 8 $^{1}/_{2}$ inches thick, in stones not less than 3 feet in length, the vertical joints to be cramped with T cramps not less than 12 inches long. Describe whether joints are to be close or channelled and whether ashlar is to be rusticked (rockworked). To provide and fix at the angles of the building, as shown upon the drawings, solid quoins of Portland (or other) stone [describe whether close, chamfered, or channelled joints and whether rusticked] of the length and height shown.
>
> **Random walling of local stone**. The stone for the walls generally is to be brought from ... (state the quarry), that for the foundations (unless brickwork is used for them) to be of large size; all those in the visible surface of the walls are to be carefully hammered, scabbled, or sawn (as the quality of the stone and nature of the work may require). All stone used in the main walls of the building to be of good scantling and no very thin stone will be allowed in any part.
>
> **A cornice and blocking course**, scantling ... by ..., moulded, to be provided according to the drawings, the bed to be such that the weight of each block of stone in the projecting part shall not equal that on the bed by one-fourth of its cubic contents. The same to be executed according to the drawings; to have proper sunk water joints and to be channelled and plugged with lead at all the joints.
>
> **Blocking course**, as shown on the drawings, ... inches high, ... thick on the bed and ... on the top, plugged with lead at all the joints, with solid block at the quoins, returned at least 24 inches.
>
> The **quoins**, jambs, **string courses**, hoodmoulds, buttress weatherings, copings and dressings generally, to be strictly worked according to detail drawings and to be dragged, chopped, tooled, or rubbed (according to the quality of the stone) so as to be truly worked in every particular.
>
> All the **tracery** and **mouldings** to be set out full size and cut and set to the right jointing, as approved by the architect or the clerk of the works.
>
> The **base mouldings** of the tower, jambs and arches of the windows and doors throughout the building

and whatsoever parts are tinted ... upon the elevations, are to be of tooled or dragged masonry.

The **plinths**, eaves, string courses and the labels over the windows and doors, are to be of Ketton (or other suitable) stone, finished with a dragged or tooled face.

The **coping of the gables** to be of Bramley Fall (or other stone that is not porous), worked as shown and the apices of the (here enumerate which) gables to be surmounted by crosses worked in Ketton or other stone, according to drawing, set with copper dowels.

Columns and pilasters, with their pedestals, capitals, bases, plinths, &c. and entablature, to be fixed as shown on the drawings. The columns and pilasters to be monoliths, or not to be in courses of more than ... blocks of stone. The architraves to be joggled from those resting on the columns or pilasters themselves and these as well as the frieze and cornice to break joint over the architrave. The architraves, if blocks of stone can be supplied large enough, to be in one block from centre to centre of column, with return architraves in like manner. The whole of the entablature (as well as the pediment, if any) to be executed with all requisite joggles and cramps (and if a pediment, the apex to be in one stone). The pilaster (if any) to be bonded not less than ... inches into the wall, against which they are placed in every other course. The sofites of the portico to be, as shown on the plan and sections, formed into panels and ornamented. Provide and let into the top of the architrave good and sufficient chain bars, with stubs on the other side for letting into every stone composing the architrave.

The **caps and bases** to piers to be in large stones. The caps and bases to dwarf shafts (if any) and the corbels under wall pieces or other roof timbers, to be well pinned into walls and sunk and dowelled to receive shafts or timbers.

To construct and fix **dressings and sills** to the external windows and doors, as shown on the drawings, with all such throated, sunk, moulded, carved, rebated and other work as may be necessary.

To describe **sills** generally:

Sills to ... windows of ... stone, 9 1/2 by 6 inches. To ... windows moulded and of ... stone, 14 by 8 inches. To ... windows of Aberdeen granite, finely tooled, 14 by 9 inches. To ... windows of ... stone, 9 by 5 inches. All sills are to be properly sunk, weathered and throated and at each end to be 4 inches longer than the opening.

Turn **relieving arches** over all arches of nave, chancel, &c., formed of different coloured stones, arranged as directed and form bands, diapers, crosses, &c., of same where shown. The stones for particoloured work to be Pennant, Caen, Temple Quiting, Red Forest of Dean, Silver Grey Forest of Dean, Red Mansfield, Whinstone, or Blue Warwickshire stone (or local stone, if of suitable colour).

Provide **shafts** where shown of Derbyshire, Devonshire, Purbeck, or other marble, or of alabaster, serpentine, Aberdeen or Peterhead granite (or other material as may be selected), to be well polished and to be sunk, dowelled and secured into caps and bases. Shafts in angles of doorways (if any) to be of any suitable dark stone (if necessary) to contrast with the jamb.

Damp Course. All the walls to have Yorkshire stone 3 inches thick and 4 inches on each side wider than the several lowest footings, in slabs of one length across the width of the footing. This was an old custom.

Balconies to a house: A balcony landing of Portland stone, ... inches thick, moulded on the edges and the pieces carefully joggled together and run with lead, to be provided with holes cut therein for the iron railing. The said balcony is to be tailed into the wall and securely pinned up.

Steps to the doorways must be described as to scantlings. All external steps should be weathered.

Flint work. Flint walling is of the following descriptions: Rough, or as the flints are dug; random, or broken without any regard to regularity; split, so that they are true on the face and oval in form; or, split and squared, by which neat and square work is produced. The walling is to be built in the soundest manner with

... flints (state which of the four descriptions is to be used), laid in mortar sharp sand, free from loam; bricks, tiles, pebbles, &c., may be bedded in the centre or core of the wall. The long flints to be selected and laid as through stones and the string-courses, &c., to be laid entirely through the thickness of the wall, so as to give additional bond. The work to be kept as dry as possible during the construction, to be protected by boards in wet weather and to be covered in as soon as possible after completion. No grouting to be used. If the walling is faced with half-flints, care is to be taken in laying them to keep their upper surfaces as level as possible, to prevent rain driving into the centre of the wall; firmly pin up the lower bed with fragments.

The **joints** of the masonry generally are to be where exhibited on the drawings and the work is to be left perfectly cleaned off, all necessary joggles, joints, rebates, moulded, sunk, weathered and throated works, grooves, chases, holes, back joints and fair edges, that may be necessary in any part of the work and all jobbing, though not particularly mentioned under the several heads, is to be performed that may be requisite for the execution of the building and all the work is to be well cleaned off before delivering it up. The whole of the work is to be warranted perfect and any damage that may occur to it by reason of frost or settlement within two years after the completion of the building is to be repaired, under the architect's direction, at the sole expense of the contractor.

All **mortar** is to be of the same quality as that described in the bricklayer's work.

[The **mortar** is to be compounded of well-burnt stone lime and sharp clean grit or drift sand (if the work be of importance), to be ground in a pugmill, or otherwise to be well tempered and beaten with wooden beaters and to be in the proportion of one heaped bushel of lime to two of sand.

(The use of sea sand is sometimes to be avoided; and road scrapings, unless very well washed and screened).]

All **cramps** to be of copper; iron cramps not to be allowed.... Lead joggles and slab slate dowels set in cement, to be inserted in the joints where directed. The contractor is to provide **lead** to run the cramps and joints.

In **stables**, granite should be provided to receive the heel-posts if cast iron be not employed and at the piers of gates, hinge and spur stones, the latter, of granite, if to be had, should be described. The caps and bases of the last can be noted only with reference to the drawings of them. The **paving of stables** and their courts is described thus: prepare the ground for paving (stating where) with good and sufficient hard materials and pave it with Aberdeen granite paving, properly dressed and sorted, 8 inches deep and 5 inches wide at the top and bottom thereof. The whole to be laid with good currents upon a layer 4 inches at least in thickness of good rough gravel, the joints of the surface to be run with stone lime and river sand grouting. It is to be well rammed and the contractor is to relay, at his own expense, all such parts as may sink within eighteen months of the work being completed.

To provide and fix under the contract ... cubic feet of ... stone, including plain work and setting thereto, also ... superficial feet of 2 1/2 inch Yorkshire paving, laid in regular courses; and in case the whole or any part of either or both should not be wanted, the quantity not used or directed shall be deducted from the amount of the consideration of the contract after the rate of ... per foot of cubic stone stone and ... per foot superficial for the Yorkshire paving, including the workmanship and fixing thereof.

Where the work is within the metropolitan district, or within a town, a sufficient **hoarding** must be erected for enclosing the premises during the execution of the works, which is to be removed and carried away when they are complete. So, also all **shoring** is to be provided, if the works be alterations, or the adjoining buildings may be injured by carrying them into effect. The shoring is to be performed in a safe, scientific and workmanlike manner, of the several fronts, floors, or otherwise as the case may be.

For a stone building: To provide, fix, maintain, alter as occasion may require and finally remove, the necessary double square fir **framed scaffolding**, travelling cranes and other implements and utensils and plant necessary for the performance of the whole of

the works; and perform all the requisite sawing, lifting, hoisting, setting and other labour that may be necessary for the carrying out the whole of the works (Gwilt, pp. 753-62).

The second set of excerpts have been extracted from the manual of F.T. Hodgson, a Canadian living in Collingwood, Ontario:

Materials

Stone

1. The whole of the stone to be of the best description of its respective kind and to be free from sand holes, vents, flaws and all other defects. Should it be disapproved it shall be removed at once from the site.

2. Any stone which will not sustain a load under test of 2-in. cube equal to ... lb, per sq. in. may be rejected and the contractor is to furnish to the architect, if demanded, fair cut cubes taken from any stone challenged by the architect and the test of such cubes shall be considered a test for all the stone of a similar character.

3. The stone...... is to be obtained from the quarry of...... to be equal in all respects to sample blocks deposited with the architect and approved by him in writing.

   Note: This clause should be repeated for each different stone to be employed in the building, to prevent the substitution of an inferior material. In no case should an architect specify particular stone by a general trade name. In the case of sandstone for sills, hearths, etc., the following clause may be used.

4. The stone is to be of an approved quarry and the contractor is to deposit samples of the stone he proposes using with the architect and obtain his approval in writing before ordering same.

• • • •

Workmanship – General Work

16. All stone work to be set in best manner, every stone wall bedded with complete full squeezed out joints in cement mortar and all work in contact with brick to be plastered with similar cement to protect from stains and all the brick backing of same to be set in similar cement mortar.

17. All stones to be well wetted before setting and large stones to be set with a derrick. Rake out mortar joints when setting.

• • • •

19. No angle miters will be allowed in any part of the work.

• • • •

21. The lines of all mouldings, curves, angles or miters to be worked to their true and proper forms and all returns of miters of mouldings, washes or bevels to be worked on and out of the solid. The beds and joints of all stonework to be square with the face.

22. All rebates for frames to be cut in the stone joints according to plans and directions of the architects. All the windows or other finishes of stone to be in size and form as shown on detail drawings, moulded, etc., according to the details of each part.

23. All stonework to be jointed as shown or directed.

24. Fix in all joints, where shown on details or as directed, copper dowels (provided by "coppersmith"), tailing equally into each stone and run with oil cement. No iron dowels, galvanized or otherwise, will be allowed and if brought on the job shall be returned immediately.

• • • •

26. Chases to be left in all walls where shown on drawings, or wherever required for the running of steam, gas and water pipes, or for any other purposes which may be found to be necessary after the work has been built.

    Cut chases and break out holes for steam, water and gas pipes, or for any other purpose.

27. The front entrance to have ... in. by ... in........ stone rubbed top and front and back-jointed step with sunk and moulded front and with short returned sunk and moulded ends.

• • • •

41. The curb to area outside .... to be 9 in. by 6 in. .... stone tooled all round with cement-plugged joints.

42. The curb to area outside .... to be similar but rebated for pavement lights.

The kitchen and scullery fireplaces to have 2 1/2 in. stone rubbed front and back hearths.

The remaining fireplaces where stone hearths are shown to have 2 in. .... stone rubbed front and back hearths.

All to be 12 in. longer than the width of opening and 18 in. projection, except to kitchen, which is to be 24 in. projection.

43. The kitchen chimneypiece to have 7 1/2 in. by 2 in. .... stone rubbed jambs and 9 in. by 2 in. .... stone mantel and shelf. The shelf to project 6 in. .... each end beyond mantel, with rounded corners and to be supported on 12 in. by 6 in. by 2 in. rubbed and moulded stone corbels cut and pinned in wall.

44. Provide and fix .... stone rubbed and dished sink in scullery 3 ft. by 1 ft. 8 in. by 5 in., all in clear, the bottom to fall and holed for grating.

Note–Glazed stoneware sinks are generally preferable to stone, except in special cases.

Provide and fix as shown 4 in. chamfered and holed top to copper, to be in one slab of rubbed .... stone.

Cut all grooves and rebates as may be required for glazing, etc., up the jambs and mullions and in the tracery and well point upon both sides with coarse putty.

47. Form rebates for iron casement frames and provide plugs and holes in stone to each.

48. Mortise steps, sills, etc., for tenons of door frame shoes and run in the tenons with lead.

• • • •

52. Provide and allow for selecting a specially jointed foundation stone and for cutting inscription on same of about .... letters 2 in. high and cutting a cavity in same and provide an airtight solid copper box to hold papers, etc., to be deposited in same and allow for extra labor and materials in setting stone with usual ceremonies. Also provide and allow for clearing up the parts of the building near the stone on the day appointed by the building owner and making the premises clear and safe and available for the usual assembly and allow for interruption of such work as necessary.

53. Thoroughly clean down all work at completion and clean out and point all joints in cement, tinted to match stone, well tucked into joints and finish with a neat flat surface.

54. Lime whiten all exterior wall surfaces, mouldings, etc.

Special Clauses for a Church

Labourers

55. The whole of the stone to be of the best description of its respective kind, to the architect's approval; to be free from sand holes, vents and all other defects; to be worked to lie on its natural bed when set and to be bedded and jointed, except where otherwise described, in mortar (or putty), with wide (or fine) joints, which are intended to show.

All the stone is to be worked on the site and particular care is to be taken to preserve all the joints of the stonework from the irregular appearance which is caused by the arrises being broken before the stones are set. No work thus injured will be allowed to be used and no patching will be allowed. The stonework to be so truly worked as not to require any cleaning off beyond washing.

56. All the dressings (unless otherwise described) to be finished off with a fine drag (or a chiselled face or rubbed) in a manner to be approved by the architect and to be bonded and fixed in the most substantial manner.

57. The vertical joints of sills, parapets, cornices and all joints in tracery of windows, in vaulting ribs and chimney caps, are to have double cement plugs and mortises for same, or double V-grooved joints run with cement as may be necessary.

58. The mullions, copings, jamb shafts, pinnacles and such are to have 1 in. or 1 1/4 in. cube slate dowels (as required) to every stone in the bed, run with cement, with proper mortises for the same.

Dressings

59. The external dressings of windows and doorways, also the copings, strings, gable crosses, weather courses, weatherings, etc., etc. are to be executed in .... All external angles of dressed stonework to be worked in the solid.

60. Provide and fix hinge and lock stones as shown on the drawings and as required. (It is sometimes advisable to make these stones of a harder material than the dressings).

61. The internal dressings, unless otherwise described, are to be of .... finished with finely rubbed surfaces.

62. All internal angles of dressed stonework to be worked in the solid.

63. The detached piers and springers over same are to be executed in .... stone. Internal detached shafts to be of .... stone (or marble, etc., etc). as required, the whole to have circular, finely-dragged faces, or to be chiseled (or rubbed), the top and bottom beds to have mortises run with cement and the intermediate joints to have light copper cramps as may be directed.

• • • •

Vaulting

65. The springers of the vaulting must be worked on the solid as shown on detail drawings; they and the wall ribs are to be built into the walls as the work proceeds, but those portions of the groin ribs which are fully developed on the springers, as well as all the filling in, will have to be set after the roof is up and covered in. The contractor is to allow for any extra scaffolding, labor, etc., that may consequently be required.

66. The cells of vaulting are to be filled in with .... stone 4 in. thick in narrow courses built in mortar, the soffits to be slightly arched or cambered and the surface to be finely dragged or chiseled to match the internal ashlaring, etc.; it is to be cleaned off and the joints struck as the work proceeds, to be properly cut up to the stone ribs and to have all necessary centering or laths that may be required for the support of the cells while building.

Sundries

67. The gable crosses to be of stone worked according to the drawings and fixed with 3 in. by 1 in. by 1 in. slate dowels run with cement.

68. The masonry in all towers to be built with special care with large flat stones, carefully bedded, each stone to break joint over the center of the stone below. Not more than .... stones to be placed in the width of the wall set in mortar and grouted as described for the other portions of the work. All joints to be true and close, filling in.

69. The tops of the turret and chimney stack are to be built as shown on the drawings, the top and cap stones of turrets and the top stone of chimney to be solid and perforated for the flues and finial rods as required.

70. A weather course to be fixed round chimney stack, also on................, all with solid springers, apex and bond stones about 4 ft. apart. (Some prefer to work these entirely on the solid).

71. The chimney-piece in vestry to be formed in................ stone, as shown by the detail drawing and to be properly doweled together and tied with copper cramps into the walls. The fender to be of stone, 3 1/2 by 3 1/2 in., rubbed and moulded, with dowels and cement plugs as required and to have circular corners as shown by the drawings.

72. The seats in sedilia, the botton of piscina, etc., to be also of .... stone, all of the widths and thicknesses shown.

• • • •

Special Clauses for a Building in a Stone District

79. The stone for wallings, footings and dressings generally to be obtained from .... quarry. (If the quarry belongs to the building owner, insert the following:— No royalty will be charged, but the contractor will have to quarry the stone and convey it to the building. The quarry to be left in good order at completion). Stone for sills, mullions, transoms, string courses, cornices, copings, weatherings and other exposed positions to be obtained from the .... quarry belonging to Mr. .... The whole of the stone to be set so as to lie on its natural quarry bed.

80. Build the footings with large flat-bedded rubble walling stones, specially selected for the purpose, in mortar thoroughly bonded, bedded perfectly level, filled in solidly and flushed up with mortar.

Properly lay up the cellar walls with good hard flat building stone ... in. thick, firm built and well bonded with a thorough stone at least in every yard super., laid in clean lime and cement mortar in parts of one of cement and two of lime, laid by and full to a line on both faces and flush and point at completion. Lay down in like manner substantial foundations under all chimneys, piers and exterior steps and all clear of frost. Leave all openings in walls for drain, gas and water pipes, as directed or as shown on plans.

81. The walls to be carried up in roughly-chiseled ashlar in mortar, to be thoroughly bonded and packed and well flushed up with mortar and small stones.

Courtesy of A. Powter, 1991

CFB Esquimalt, BC

82. The inside face to be carried up true and even in brickwork to receive plaster (4 1/2 in. lining properly bonded with headers into wall).

83. The outside surface to be executed in roughly-chiseled ashlar (the local rubble stone in horizontal random courses to average 7 in. on bed with one bond stone at least to every yd. super., the beds to be roughly hammer dressed and the surface to be chopped to remove any great irregularity as shall be directed, the courses to vary from 3 in. to 7 in. high and in stones between 14 in. and 24 in. long with occasional large square stone). The pointing to be done as the work is carried up by passing the point of the trowel over the joint, so that the mortar shall in no case project over any portion of the stones and the joints to be slightly weathered.

84. The quoins to be got out of the best local weather stone, to be long each way on the bed and well bonded into rubble walling, the angles to be truly formed and the surface to be axed with irregular upright and diagonal strokes as shall be approved, or, if of rubble, "the quoins to be executed in selected large stones."

85. Provide for covering the tops of walls with asphalted felt if they should be uncovered during frost or very wet weather (Hodgson, pp. 275-96).

5.0 BIBLIOGRAPHY

Arthur, William. 1926. *New Building Estimators' Handbook*. Scientific Book Corp., New York.

Baker, Ira O. 1897. *A Treatise on Masonry Construction*. John Wiley & Sons, New York.

Blondel, J.F. and M. Matte. 1777. *Cours d'architecture ou trait de la décoration, distribution et construction des bâtiments*. Vol. 5. Chez la Veuve Desaint, Paris.

Brooks, F.W. 1961. *Masons' Marks*. No. 1. East Yorkshire Local Historic Society.

Burrell, E.J. 1893. *Advanced Building Construction, A Manual for Students*. Longmans and Green, London.

Emergy, Thomas J., and Frank D. Graham. 1945. *Audels Masons and Builders Guide No. 4*. Vol. 4. Theo. Audel, New York.

Fowler, William H. 1946. *Fowler's Architects, Builders and Contractors Pocket Book*. Scientific Publishing, Manchester.

Gwilt, Joseph. 1891. *An Encyclopedia of Architecture, Historical, Theoretical and Practical*. Longmans and Green, London.

Hodgson, Fred T. 1905. *20th Century Bricklayer's and Mason's Assistant*. Frederick J. Drake, Chicago.

Jones, G.P., and Douglas Knoop. 1967. *The Medieval Mason*. University Press, Manchester.

Lowndes, William S. 1907. *Building Stone Foundations-Masonry*. International Textbook Co., Scranton.

Macey, Frank W. 1922. *Specifications in Detail*. Crosby Lockwood and Son, London.

McKee, Harley J. 1973. *Introduction to Early American Masonry, Stone, Brick, Mortar and Plaster*. National Trust for Historic Preservation and Columbia University, Washington, DC. Quoted material and illustrations reprinted by permission: Copyright 1973, National Trust for Historic Preservation in the United States.

Moxley, Raymond. 1961. *Mitchell's Elementary Building Construction*. B.T. Batsford, London.

Parker, John H. 1882. *A Concise Glossary of Terms Used in Grecian, Roman, Italian and Gothic Architecture*. Parker, London.

Sutcliffe, G. Lister. 1899. *The Principles and Practice of Modern House Construction*. Vol. 1. Blackie and Son, London.

Taylor, A.D. n.d. *Stonework for Walls, Some Notes and Details Concerning Textures*. Unknown source.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

4.2
PERIOD MASONRY
CUT STONE WORK

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: D. BOUSE/G. SHEMDIN

CONTENTS

1.0 INTRODUCTION

Although stone is the oldest building material, quarrying and dressing methods have changed relatively little over the years. Dressing, particularly, remains a handcraft. The attitude towards stone has not changed. Even though it is now more often used as a veneer and not for the structure itself, it still "projects a picture of well established importance." Seen as a durable, longlasting fabric, it has traditionally been the obvious choice for buildings designed to impress.

1.1 CUT STONE IN CANADA

Stone building in Canada goes back to the earliest settlements in the country. In 1641 Mother Superior Marie de l'Incarnation of the Ursuline Order in Quebec wrote that their house was made entirely of stone and measured 92 feet by 28 feet. She also noted that the houses of the Reverend Fathers, the hospital nuns and "settled" Indians were of stone as well (Traquair, p. 10).

A century later, a stone building tradition was established in Nova Scotia by Scottish settlers. The building of the Rideau Canal, 1826-32, brought an influx of stonemasons from Scotland and Ireland, who developed stone building skills in Ontario. These in turn spread to the Prairies as seen in the stone buildings at Fort Garry, Manitoba, erected in the 1830s.

Because of the difficulties and expense of transporting stone, concentrations of domestic stone buildings are usually found in areas adjacent to stone sources. In Canada outcroppings of suitable stone such as granite, limestone and sandstone largely are found in eastern Canada. The most notable western stones are tyndall in Manitoba and the sandstone of Alberta. However, despite the availability of stone itself, quarrying and dressing it were, and still are, expensive operations. Early stone houses usually had cut stone only for door and window trim. The use of dressed stone for walling was restricted to civic buildings, churches and major dwellings. Ornamental details for more important buildings such as columns, pilasters, brackets and coping were made with cut stone, as were arched openings. For the latter, whether semi-circular, pointed or segmental, the stones were cut to predetermined shape; for segmental arches these would have been slightly wedge-shaped "voussoirs," held in place by compression. Stone quoins, originally a structural feature designed to add stability to the corners of the building, became an important decorative feature of the Gothic Revival style (1860s) and were often cut to provide an accent: sometimes with chiselled margins and rock face or smooth with bevelled edges to cast a deep shadow line.

Carved ornamental detail was an integral part of the structures of the Neo-classic era (ca. 1830-50) and of the later Gothic Revival (1860s). Flowers, foliage, animals and heads all appeared, with or without a symbolic basis, in both exterior and interior designs. Originally hand carved in stone, many were subsequently mass produced in plaster or concrete – usually a poor substitute for the lively craftsmanship that produced the original. Also, by the late 19th century, stone used as a structural material had largely given way to brick which was cheaper and easier to erect.

Photo courtesy of CIHB

Decorative Stonework. Stone church in Saint John, NB.

1.2 CLASSIFICATION AND TYPES OF STONE

Classification and types of stone are well detailed in numerous publications. The following brief summary is from *Construction Materials and Processes* by Don A. Watson. The three basic classes are: igneous, formed by heat and pressure such as volcanic action; sedimentary, formed by the compression of fossil remains; and metamorphic, the result of changes in the chemical composition or recrystallization of either of the other two. The most common types are:

Granite (igneous) – a very hard stone used where strength is required. While it is very difficult to carve, it can be polished to a very bright finish.

Sandstone (sedimentary) – a soft stone, easy to work but not always durable. Sometimes known as brownstone or redstone, it is used for trim and carved decorative details.

Limestone (sedimentary) – comparatively soft when quarried but hardens on exposure to air; widely used both for structure, finish and detail.

Marble (metamorphic) – a crystalline limestone; varies considerably in colour and in weather resistant qualities. Originally used for structure, it is now used as a veneer or for flooring and, on occasion, in translucent panels for window openings (Watson, pp. 93-94).

Considerable variation in colour and general appearance is found within these types. Very often several types from different quarries are combined in one building. For example, the original Parliament Buildings used a buff coloured sandstone from Nepean as a fill, Ohio sandstone for dressings, gables and pinnacles, red sandstone from New York and dark grey slate from Vermont. The 1916 building used wallace sandstone from Nova Scotia for chimneys, courts and light wells and tyndall stone from Manitoba for interior corridors and stairs.

1.3 QUARRYING METHODS

Quarrying methods, even with some mechanization, remain labour intensive. There were basically two methods used: splitting with iron or wood wedges and with dynamite. The latter tended to shatter the stone (and also to shatter the quarrymen, because many were inexperienced in handling it). Holes were hammered into the rock at given spaces, the dynamite inserted and set off.

Soft or striated stone could be split by first hammering a series of closely spaced holes and inserting a wooden wedge in each. When wetted down, the wedges swelled, cracking the stone along the line of the wedges – a method used by the Romans. More customary was the "plug and feather" method. In lieu of the single wooden wedge, a pair of semi-circular shaped iron pieces having an inner taper (the "feathers") are driven into each hole and an iron wedge – the "plug"– hammered in between them, which cracks the stone along the wedge line.

These same methods are used today, but the holes are mechanically drilled. In some quarries, steam driven channelers (first patented in the 1840s) are used to separate the rock and in other modern quarries, the cutting is done by mechanically operated wires.

1.4 STONE DRESSING

Dressing the quarried stone was originally done entirely by hand. Today the chisels and hammers used for surface finishing can now be mechanically driven, large pieces such as columns turned by machine on a lath and initial cutting done by gangsaws.

Stone finishing or dressing, described and illustrated by Harley J. McKee in *Introduction to Early American Masonry*, was summarized under the following headings:

- hewing with ax or pick
- hammering with ax or hammer
- working with chisel driven by mallet or hammer
- sawing
- rubbing with an abrasive.

In general, hammering was used for hard stone such as granite; softer stones were hewn or chiselled; sawing was used to form marble slabs and rubbing for a final finish. The most common surface finishes are:

Rough and fine pointed – a series of non-continuous grooves 25 mm or 10 mm apart respectively.

Bush hammered – a series of closely spaced indentations produced by a hammer which has two square faces with pyramidal points 50 to 150 mm apart.

Chiselled – a series of closely spaced parallel lines or an uneven "rock faced" finish – very often combined with a chiselled border around rock faced surface.

For ornamental work, templates were prepared from the master design and the stone chiselled out by hand.

1.5 ASHLAR

Ashlar is a squared, dressed stone usually set in even courses with a very fine mortar joint. It may be surface dressed or surface interest may be provided by the colour or pattern of the stone itself. Originally used structurally, solid ashlar walls gave way by mid-19th century to slabs used as a veneer only, attached to the structural backing by tie wires or metal anchors of varying design.

The use of ashlar for walling or surfacing usually, but not necessarily, required a master plan detailing and numbering all pieces to guide the mason both in preparation and final installation.

1.6 STONE PAVING

Little evidence suggests that any early Canadian streets were paved in the Roman manner, with cut stone set on a gravel and concrete base. Rather, paving in early cities was cobblestone or brick. Flagstones from the lakeshore were used to a very limited extent in early 19th-century Toronto, but proved to be rough and uneven in surface and setting. Crushed stone was used to fill the mudholes in the unsurfaced streets and later as a surfacing, particularly for roads.

A pamphlet written in 1841, detailing the size, grade, drainage, etc., recommended for roads in Upper Canada, referred to gravel or broken stone as the finished surfacing. Use of broken stone became common apparently, but was often too coarse and not well enough compacted to be very satisfactory. With the introduction of macadamizing in the 1830s, the situation gradually improved. Because there was an abundance of wood available – particularly where roads were cut through unlogged land – use of planks to surface roads was more popular than paving of any kind. A visitor to Toronto in 1839 wrote:

The centres of all the streets are either paved or macadamized; and the sidewalks are chiefly, though not entirely, of wooden plank, placed longitudinally as on a ship's deck, and forming a far more clean, dry, elastic and comfortable material for walking on than any pavement of stone or brick. In the few instances, indeed, in which flat stone pavement is used instead of wood, it is extremely disagreeable to pass from the latter to the former (Guillet, p. 122).

2.0 BIBLIOGRAPHY

Foster, Michael., ed. 1982. *Architecture: Style, Structure and Design*. Excalibur Books, New York, p. 29.

Guillet, Edwin C. 1966. *The Story of Canadian Roads*. University of Toronto Press, Toronto, pp. 64, 122.

Hutchins, Nigel. 1982. *Restoring Houses of Brick and Stone*. Van Nostrand Reinhold and Fleet Publishers, Toronto.

Lund, C., and Malak. 1967. *Stones of History*. The National Film Board, Ottawa.

McKee, Harley, J. 1977. *Introduction to Early American Masonry: Stone, Brick, Mortar and Plaster*. 2nd printing. National Trust for Historic Preservation, Washington, DC, p. 20.

Traquair, Ramsay, 1947. *The Old Architecture of Quebec*. The MacMillan Co. of Canada, Ltd., Toronto, p. 10.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

5.1
PERIOD BRICKLAYING AND TILING
BRICKWORK

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: L. KONICEK

CONTENTS

1.0 INTRODUCTION

This article deals with certain categories of plain brickwork. It provides information on the traditional processes of building assemblage and the techniques of execution, a description of field practice, a list of references and sample specifications.

This information will aid professional staff both during the investigation phase by identifying the historic assembly techniques and construction details and during the project design phase, by specifying appropriate consolidation and reconstruction processes.

2.0 PLANNING OF BRICKWORK

2.1 THE SELECTION OF BRICK

The criteria for choosing a particular type of brick today are much like those of the past. The required physical properties, appearance and availability continue to be prime considerations.

A specification dated October 10, 1839 for Beth Elohim Synagogue, in Charleston, SC, was quite specific:

> Materials for all the foundations walls arches etc. to be of the best quality Carolina Grey Bricks: The pediments, architraves to windows, columns, cornices, triglyphs etc. may be of best northern well-burned bricks... (McKee, p. 77).

Based on apparent physical properties, brick was sorted by the manufacturer into two classes – common brick and stock brick. Common brick was the softer of the two and had acceptable dimensional irregularities. It was used for those parts of walls that were covered.

Stock bricks were harder, more regular and more uniform. They were placed on the outer face of the wall, because they resisted weathering better and were more attractive. Toward the end of the 19th century, stock bricks were called facing bricks.

For more details concerning the properties of brick, see Vol. VI.2.1 "Masonry: Structure and Properties."

2.2 TYPES OF MORTARS USED

Several properties have traditionally been considered when selecting a particular mortar: cohesiveness, adhesiveness, strength, setting time, ease of handling, ability to set and harden under water (hydraulic quality) and the degrees of expansion and solubility. The visual properties of colour and texture were also considered.

"It is essential to distinguish between hard and soft mortars. The use of lime-sand mortars predominated until about 1880" (McKee, p. 61). Many structural systems depended upon some flexibility of the masonry components. A cushion of soft mortar was sufficiently flexible to compensate for uneven settlement of foundations, walls, piers and arches and to allow for gradual adjustment over months and years.

"Clay, the first material to be used for soft mortar, has been used throughout history in walls of unburned brick" (McKee, p. 61). Joints filled with clay mortar could bear heavy loads, but in humid climates they needed protection. Judge Samuel Yewall recorded a disaster which occurred in Massachussets:

> October 30, 1630, a stone house which the governor was erecting at Mystic was washed down to the ground in a violent storm, the walls being laid in clay instead of lime (McKee, p. 61).

Lime-sand mortar was the most common soft mortar used for walling which would not be subjected to continuous wetting. The improvement in brick manufacture throughout the 19th century, resulting in a stronger brick, had much to do with the declining use of soft mortars.

Natural cement appeared as a mortar ingredient as early as 1819. In areas where masonry was subjected to continual wetting and where great strength was required, it had an immediate use. Because cement mortars were harder than lime mortars, joints filled with them were strong and unyielding.

In the 1850s, architect T.V. Walter wrote:

> I have to request that all the mortar used in every part of the work be mixed in proportions by actual measure, as follows. For all the footings, to the height of 2 feet above the bottom of the cellars and for the

> backing behind the granite sub-basement, cement and sand, without any lime, in proportions of one of cement to two of sand. For all the rest of the work, in proportions of one of cement, three of lime and eight of sand (McKee, p. 69).

Artificial cement – known generally as Portland cement – came into general use as a mortar ingredient after 1880. Its strength, low absorbency and hardness were well matched to the bricks of that period.

In 1896, F.E. Kidder gave the following recommendations for application:

> Cement mortar should be used for all mason work which is below grade or situated in damp places and also for heavily loaded piers and arches of large span....
>
> For construction under water and in heavy stone piers or arches... Portland cement should be used; elsewhere material [natural] cement will answer (McKee, p. 69).

2.3 QUANTITIES

2.3.1 Bricks

Estimating the number of bricks in a wall would be a simple operation were it not for the space taken up by the mortar, which can vary from 3 mm to 10 mm. Historically, two methods of making this calculation were used, a volume method and an area method. A description of both methods with representative examples of estimating follow.

a. Volume method
The space taken up by each brick and mortar in the joint will depend upon how many bricks are used on the outside surface of the wall and how many are entirely covered by mortar, as in the case of bricks in the centre of the wall. Another factor is whether the bricks are stretchers or headers.

The general rule for quantity estimation can be stated as: determine net volume of the brickwork (deducting openings) and divide by volume of unit brick and mortar.

b. Area method
Using this method, one computes the net area of the surface of the brickwork and multiplies the square metres thus found by the number of bricks required per square metre. The results are only an approximate figure.

2.3.2 Mortar

In the bricklayer's handbooks and guides published in this century and the last, there was frequently a table giving the quantities of material needed to produce a particular mortar for laying a particular number of bricks (usually 1000) using a particular thickness of mortar joints.

One suspects these tables were used more by the builder or architect than by tradespeople, who presumably had their own rules of thumb.

The table below is based on laying 1000 bricks with 10 mm joints.

PROPORTIONS	**QUANTITIES**		
	Cement	Lime	Sand
Cement Mortars 1 part cement 2 parts sand	$1^3/_4$ bbls.	$^1/_4$ bbl optional	$^1/_2$ cu. yd.
1 part cement $2^1/_2$ parts sand	$1^3/_8$ bbls.	$^1/_4$ bbl optional	$^1/_2$ cu. yd.
1 part cement 3 parts sand	$1^1/_8$ bbls.	$^3/_4$ bbl optional	$^1/_2$ cu. yd.
Lump Lime Mortar 1 part lime 2 parts sand		$^7/_8$ bbl	$^1/_2$ cu. yd.
1 part lime $2^1/_2$ parts sand		$^3/_4$ bbl	$^1/_2$ cu. yd.
1 part lime 3 parts sand		$^1/_8$ bbl	$^1/_2$ cu. yd.
Hydrated Lime Mortar 1 part lime 2 parts sand		3 $^1/_2$ sacks	$^1/_2$ cu. yd.
1 part lime $2^1/_2$ parts sand		3 sacks	$^1/_2$ cu. yd.
1 part lime 3 parts sand		2 $^1/_2$ sacks	$^1/_2$ cu. yd.
Cement-Lime Mortars 1 part cement 1 part lime 6 parts sand	$^1/_2$ bbl.	1 sack hydrated or $^1/_4$ bbl lump lime	$^1/_2$ cu. yd.
Grout for $^3/_{16}$" - $^1/_4$" joints 1 part cement 3 parts sand	approx. $^3/_4$ bbl.		approx. $^1/_3$ cu. yd.

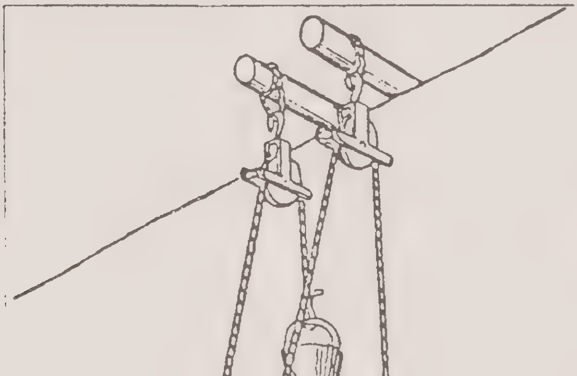
Table showing mortar required per 1000 bricks with 10 mm joints (Graham, p. 404).

For other thicknesses of joints, the same source suggests that "...about 1/3 more or less mortar for each 3 mm difference would be required."

The quantities given assume a barrel of Portland cement weighs 172 kg, a barrel of lump lime, 82 kg and a sack of hydrated lime, 23 kg.

Portland cement was usually bought in bags of 42 kg net or by a barrel of 170 kg. When proportioning, it was assumed to weigh 45 kg per cubic metre.

Lump lime was sold by the bushel, the weight of which varied from 34 to 39 kg net. It was also sold by the barrel. An 82 kg barrel contained 0.09 cubic metres and a 127 kg barrel contained 0.13 cu. metres. The weight of a cubic metre of lime varied from 27 to 34 kg net.



Bricklayer's Hoist. A 19th-century Example of an Old Type: the Windlass (McKee, p. 56)

2.4 LABOUR

2.4.1 Mixing Mortar

A labourer experienced in mortar mixing would slake, sand and stack about 11 barrels of lime per eight-hour day. The time required for mixing and tempering mortar per 1000 bricks varied from 1 to $1^1/_2$ hours, depending on the thickness of mortar joints. These figures applied for both lime and cement mortars. For lime mortar, it also included the time required for slaking the lime. One mortar mixer was expected to supply eight bricklayers (Graham).

2.4.2 Laying Brick

On large ordinary works, bricklayers were able to lay 1500 bricks per day, including facing and backing. For special work such as pilasters, where special patterns had to be formed on the surface of the wall or for cornice work, the bricklayer's time was increased according to the type of work to be done.

Each bricklayer needed assistance in handling mortar, passing up brick from the pile on the ground, moving scaffolding, etc. According to *Audel's Masons and Builders Guide*, one bricklayer required 1 to 1.3 helpers.

The helper's time for cleaning brickwork is not included in the above estimate. If cleaning and scrubbing brickwork with muriatic acid was needed, estimates suggest that a man could clean about 0.8 m^2 per hour (Graham).

2.5 TRANSPORTATION

Before the 20th century, most brick was manufactured locally, partly because of its bulk and weight and partly because the clay and sand from which it was made were found almost everywhere. Long distance transportation was practically excluded.

In the 20th century, differential freight rates facilitated the shipment of brick and made brick shipped from a distance competitive in price with locally made products.

On the site, material first had to be hauled by cart or wheelbarrow from a storage space to the actual place of construction. Economical planning of storage spaces on the building site helped to minimize the length of the transportation path of materials and thus reduced the cost of construction.

2.6 SEASONAL CONSIDERATIONS

The harsh climate in many parts of Canada had to be considered when contemplating brickwork. As it was not possible to lay brick in low temperatures unless special and expensive precautions were taken, work on the superstructure was usually scheduled from spring to autumn. Interior work was frequently done from late fall to early spring.

3.0 BRICKLAYING

3.1 MORTAR PREPARATION

3.1.1 Common Lime Mortar

This widely used mortar was composed of quicklime or slaked lime mixed with sand and water. Details of its preparation varied according to regional customs and individual preferences. The builder was always aware of more methods than he practised.

Mortar was prepared for use by the following basic methods:

1. Dry pulverized quicklime and dry sand were mixed. Water was then added and the whole mass was mixed.

2. Dry sand was added to lime paste and thoroughly mixed in. If necessary, water was added.

3. Slaked lime powder, sand and water were mixed together, either simultaneously or by adding water to previously mixed lime and sand (McKee, p. 64).

The lime was slaked by one of the four methods described in the same source as follows:

a. Sprinkling or drawing:
   The correct amount of water was sprinkled onto quicklime. The lumps cracked open and dry powder was formed.
b. Immersion:
   Quicklime was placed in a basket, lowered into water and drawn up in time to complete the slaking action in the air. The correct time of immersion was a critical factor which was difficult to determine.
c. Exposure:
   Quicklime was simply exposed to the air in a shed or shelter for a considerable length of time. It absorbed moisture from the air and became partially slaked, but it also absorbed carbon dioxide and thus acquired inert

material calcium carbonate that adulterated the slaked lime. This method was universally considered the least satisfactory one.

d. Making lime paste
Quicklime was placed in a pit or a vat and more water than the amount required for slaking was poured over it. The mixture was allowed to stand and slake. This lime paste was either used at once or stored in a covered pit for months or years (McKee, p. 63).

Thorough mixing or beating of mortar just prior to its use was emphasized by most builders. In 1823, Peter Nicholson recommended a practice which was probably well established in North America:

> Before the mortar is used, it should be beaten three or four times over, so as to incorporate the lime and sand, and to reduce all knobs or knots of lime that may have passed the sieve. This very much improves the smoothness of the lime, and, by driving air into its pores, will make the mortar stronger: as little water is to be used in this process as possible. Whenever mortar is suffered to stand any time before used, it should be beaten again, so as to give it tenacity, and prevent labour to the bricklayer. In dry hot summer weather use your mortar soft; in winter, rather stiff. If laying bricks in dry weather...wet your bricks by dipping them in water, or by causing water to be thrown over them before they are used... (McKee, p. 65).

Between 1777 and 1780, B. Higgins carried out experiments which helped establish the basis for improved practice in preparing and handling lime. He also demonstrated that, contrary to a widespread belief, fresh lime made better mortar than lime that was kept as a paste for a long time. Following a certain amount of experimentation, he concluded that:

> ... mortar grows worse every hour that it is kept before it is used in building, and that we may reckon as another cause of the badness of common mortar, that the workmen make too much at once, and falsely imagine that it is not the worse, but better, for being kept some time (McKee, p. 66).

After being mixed, common lime mortar remains plastic for several hours. It must be placed in the wall while in this condition. Mortar is said to have set when it loses its plasticity. When set, it will support the load of masonry placed on it.

3.1.2 Hydraulic Mortar

Mortar is said to be hydraulic if it will set in water. It can be of several different compositions:

- common lime plus pozzolana plus water
- hydraulic lime plus sand plus water
- cement (natural or Portland) plus sand plus water.

Some pozzolana was brought to North America during the 18th and 19th centuries. Its use for mortar preparation was, however, not very common.

"Hydraulic lime results when "impure" limestone containing clay… is burned in the same manner as common lime" (McKee, p. 67). Early American builders probably used this material for making mortar without being aware of its special qualities.

After 1819, natural cement mortar was used mainly in areas where masonry was subjected to moisture and great strength was required.

Portland cement became a major ingredient in mortar after 1880. Its strength, absorbency and hardness were well matched to the bricks made after this date.

3.2 BONDING

Bond in relation to brickwork means the arrangement of the bricks whereby:

- an adequate distribution of load is obtained through the mass of brickwork
- the mass is tied together so that any individual brick is not easily displaced
- some uniform and pleasing arrangement of the brick faces appears on the face of the wall.

It is supposed that the period bricklayer was familiar with two types of bonding at most. On special request he was able to lay bricks in a particular manner, providing the bond was clearly specified.

Some basic types of bonding used throughout the history of bricklaying are briefly described and illustrated below.

3.2.1 Bonding in Typical Wall Sections

The two main bonds in use for good class work are English and Flemish bond. Each has a distinct face appearance.

English bond: shows alternate courses of headers and stretchers in elevations.

Flemish bond: shows alternate bricks in the same course as header and stretcher. The header of one course lies in the centre of the stretcher in each of the courses above and below it.

Though several bonds have acquired special names among builders, they are all either a combination or variation of English and Flemish bonds. These include:

Single Flemish: flemish bond is used on the face of a wall with brick laid in English bond as a backing;

Stretching: all bricks are laid as stretchers. This bond is suitable for walls 114 mm thick and for facing a thick wall with special kinds of facing brick;

Heading: is sometimes used for panelled work. It is particularly suited to work which is curved in plan;

Brick-on-edge heading: is appropriate for thick walls. The wall may be of any thickness from 230 mm upwards;

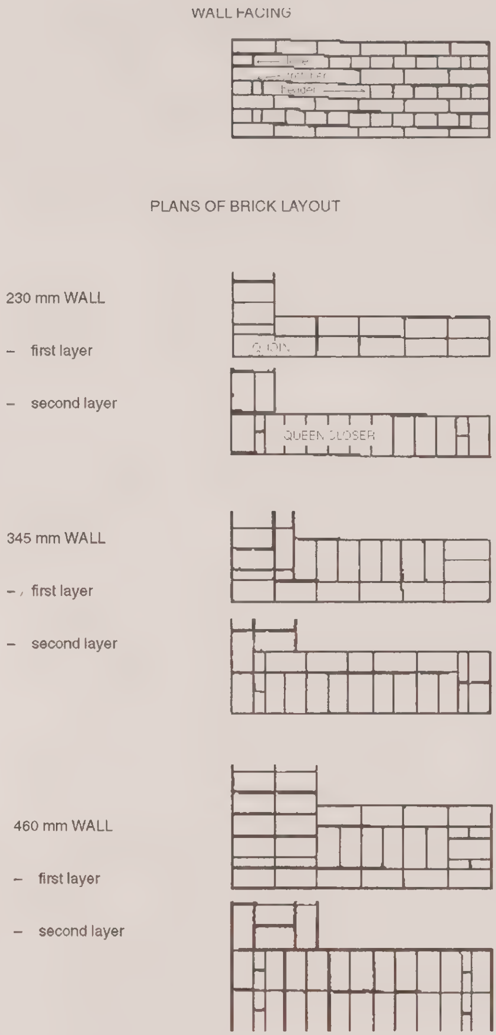
Brick-on-edge stretcher: appropriate for thin walls and partitions;

Dutch bond: avoids the use of closers in starting the bond. Three-quarter bats are used in the stretching courses to obtain the position of the first stretcher joint and a header is inserted after this three-quarter bat in alternate courses, which breaks the continuity of the vertical joint so that they occur only in alternate stretching courses;

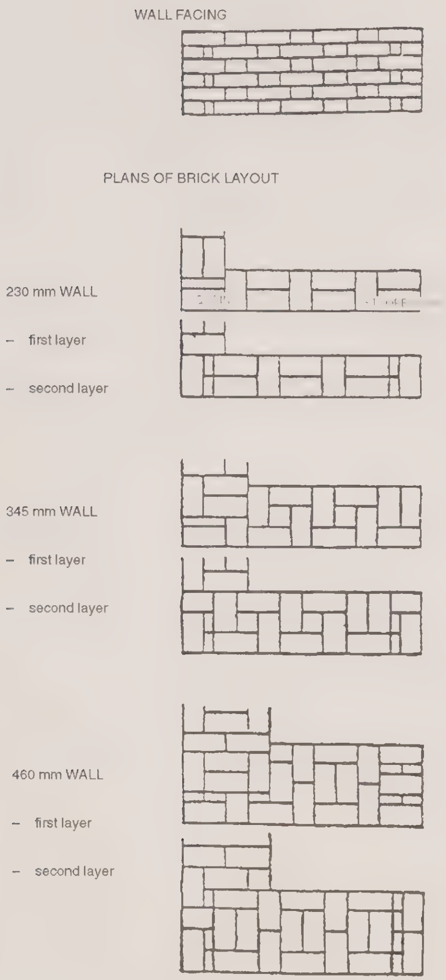
English cross: a header is inserted after the first stretcher in each stretching course; and

Garden wall: the wall is built in a true Flemish course mixed with three or more stretchers.

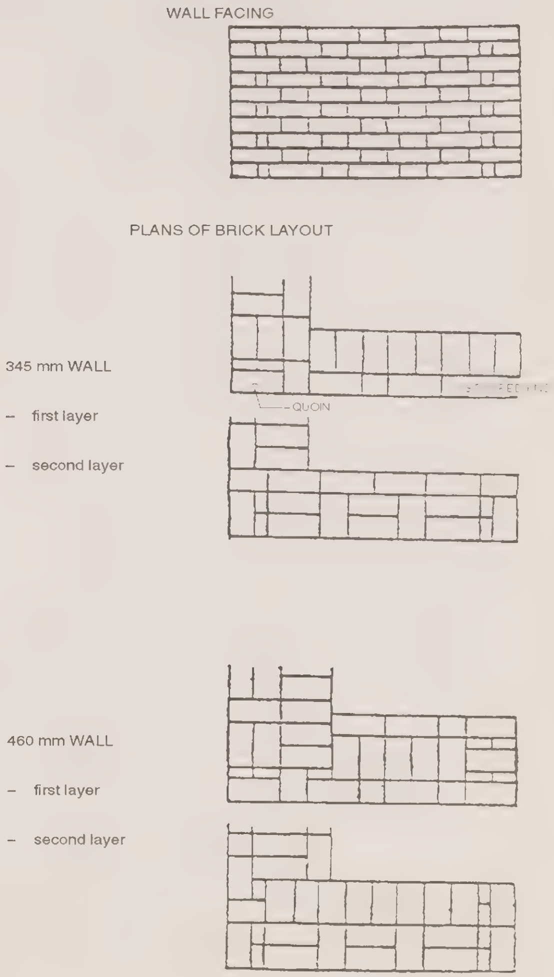
For more details on bonding, see the bibliography.



English Bond – wall facing with examples of plans of brick layouts for different thickness of wall, arrangements of brick in wall corners and end-sections

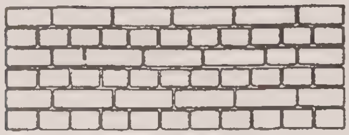


Flemish Bond – wall facing with examples of brick layouts for different thicknesses of wall, arrangement of brick in wall corners and end-sections

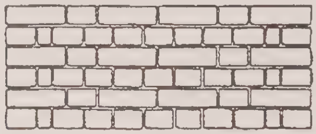


Single Flemish Bond – wall facing with examples of brick layouts for different thicknesses of wall corners, end-corners and end-sections

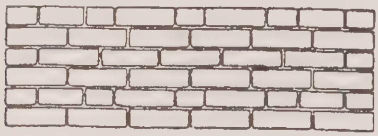
DUTCH BOND



ENGLISH CROSS BOND



GARDEN WALL BOND



Wall faces in Dutch bond, English cross bond and garden wall bond

3.2.2 Bonding in Square Quoins and Squint Quoins

A quoin is an external angle of a wall. In most cases, the angle is laid in 90° and is known as a square quoin. When the quoins are formed by walls at acute or obtuse angles, they are called squint quoins.

The general principle for laying square quoins is quoted in *The Bonding of Brickwork*:

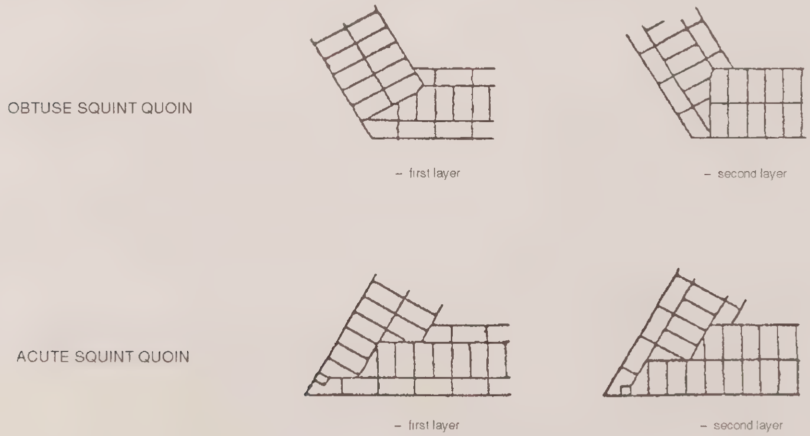
> ... allow the stretching face course to run through to the angle and so form a header on the return face, then to butt the whole of the heading course of the return wall against these stretchers (Frost, p. 6).

The same principle is adopted for Flemish and single Flemish bonds as for English bond, interpreting the stretching course to mean the course which commences with a stretcher (Frost).

For laying squint quoins:

> The principles are the same as for square quoins but a difficulty occurs because the splayed end of the first stretcher measures more than the normal width of a brick. This brick is therefore reduced by a splay cut (which may be long or short) and a tapered closer is usually inserted, although the exact form may be varied considerably... (Frost, p. 7).

An example of the 460 mm wall laid in English bond, forming obtuse and acute squint quoins, is shown in the following illustration. For more details, see Hodgson, Dalzell and Townsend and Frost.



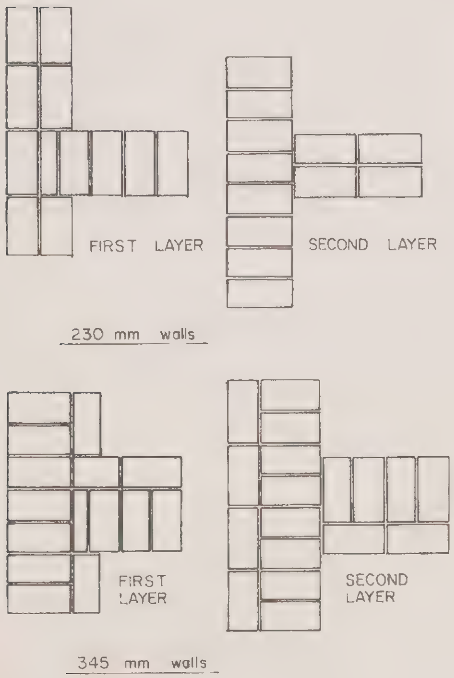
Obtuse and Acute Squint Quoins – 460 mm Wall Laid in English Bond

3.2.3 Bonding in Wall Junctions

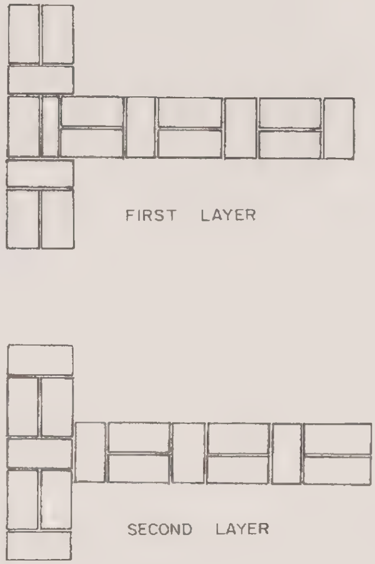
One of the most comprehensive sources describing principles of bonding in junctions is *Bricklaying Skill and Practice*.

a. Square junctions in English bond:
The principle in every case is to allow the heading course of the abutting wall to enter 2 1/4 in. into the stretcher face of continuous wall and to make up the remaining 2 1/2 in. by queen closers.

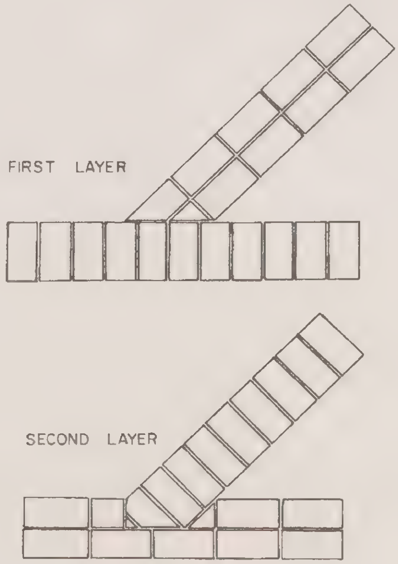
b. Square junctions in Flemish bond:
The principle is the same as that adopted for English bond junctions, with slight variations and adjustments which are required by the alternating header and stretcher in the same course.



Square Junctions in English bond



Square Junction of 230 mm Walls in Flemish Bond



Splay Junction of 230 mm Walls in English Bond

c. Splay junctions:
The principle of joining two walls which meet on the splay (any angle other than right angle) is to adapt the previous method of allowing the heading course of the abutting wall to enter the stretching face of the continuous wall by at least 2 $^1/_4$ in. and to butt the stretching course (by splayed cutting) against the continous wall. Awkward cutting cannot be avoided in these cases.

d. Cross junctions:
Where two walls of the same or different thicknesses cross each other at right angles, alternate courses run through.

3.2.4 Bonding in Reveals and Jambs

The vertical sides of window or door openings between the faces of wall and window or door frames are called reveals. The remaining parts of vertical sides are called window or door jambs.

Some examples of how to lay bricks in reveals in English bond and splayed jambs in single Flemish bond are shown in a following illustration. More details can be found in Hodgson, Dalzell and Townsend and Frost.

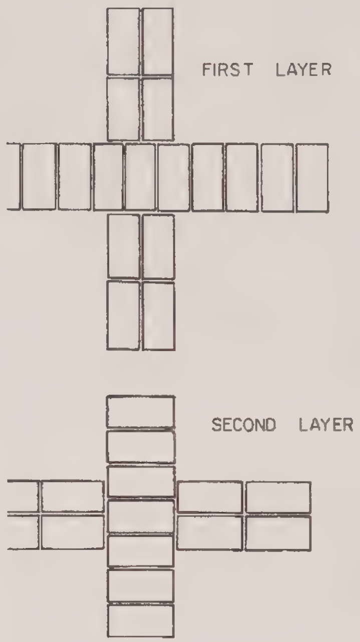
3.2.5 Bonding in Piers

According to their position in relation to surrounding walls, piers can be classified as isolated or attached. The following principles are applied for their bonding:

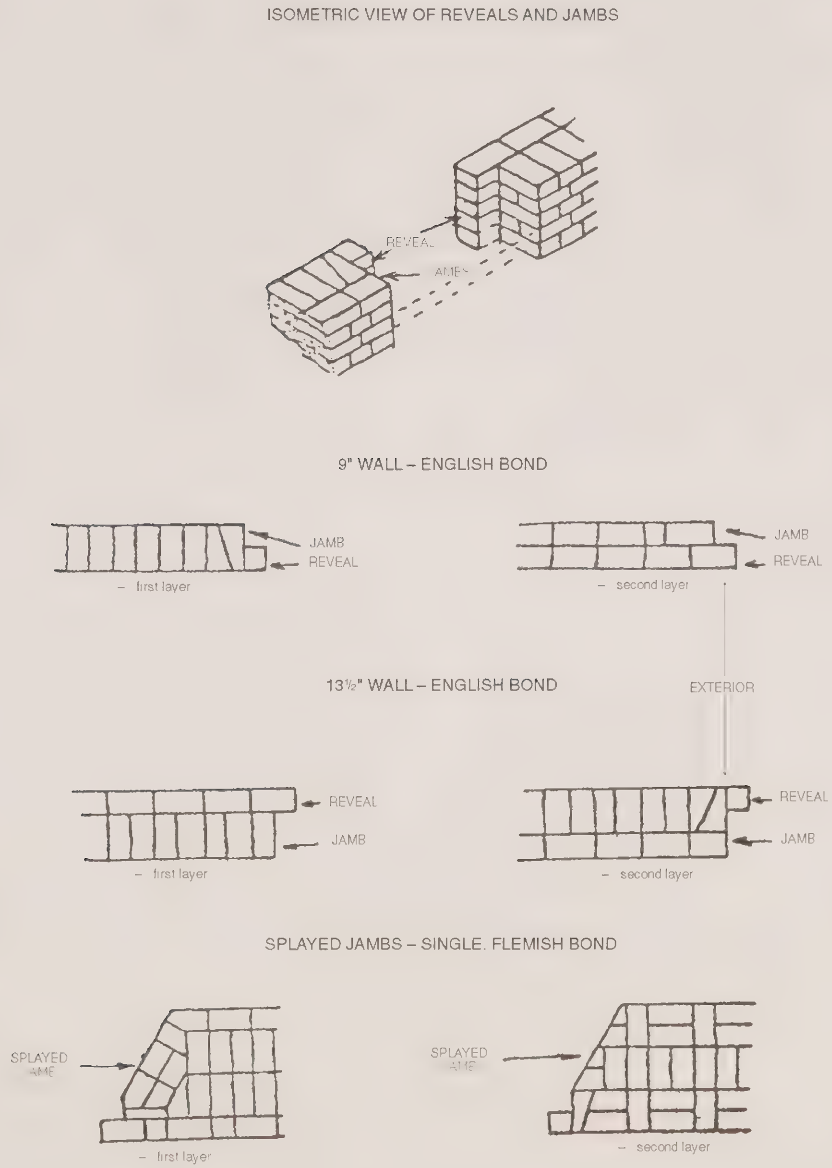
a. Isolated piers:
Some examples of bonding in piers in English and Flemish bonds are shown in illustration.

b. Attached plain piers in English bond:
Take note of the heading course of the pier entering the stretching course of the wall in each case; bevelled cutting only occurs in the stretching course of the pier.

c. Attached plain piers in Flemish bond:
A similar principle to that of English bond is followed, except that where the bonding is to Flemish bond walls, bevel bats and king bats and closers are employed.

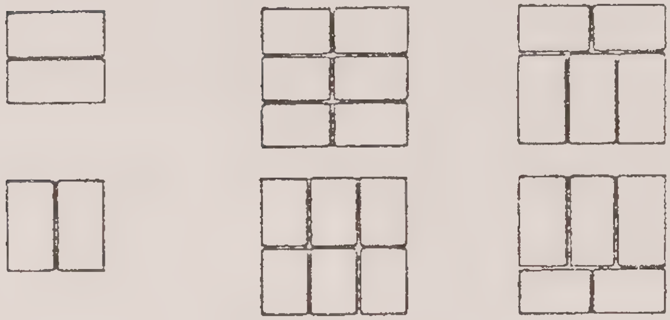


Cross-junction of 230 mm Walls in English Bond

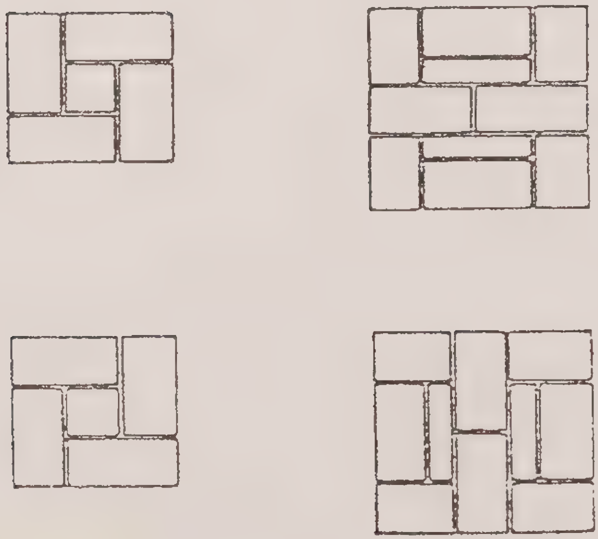


Plans of Reveals and Splayed Jambs

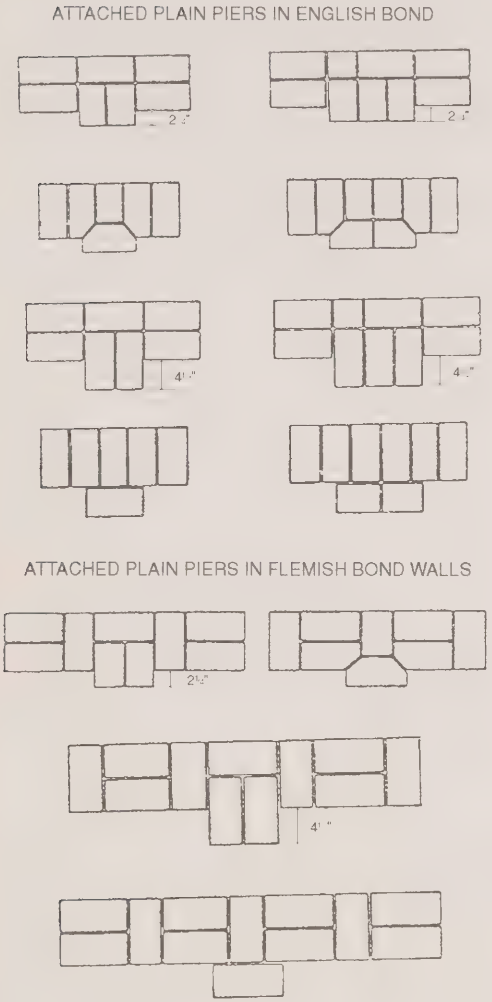
ISOLATED PIERS: ENGLISH BOND



ISOLATED PIERS: FLEMISH BOND



Bonding of Isolated Piers – Examples of English and Flemish Bonds



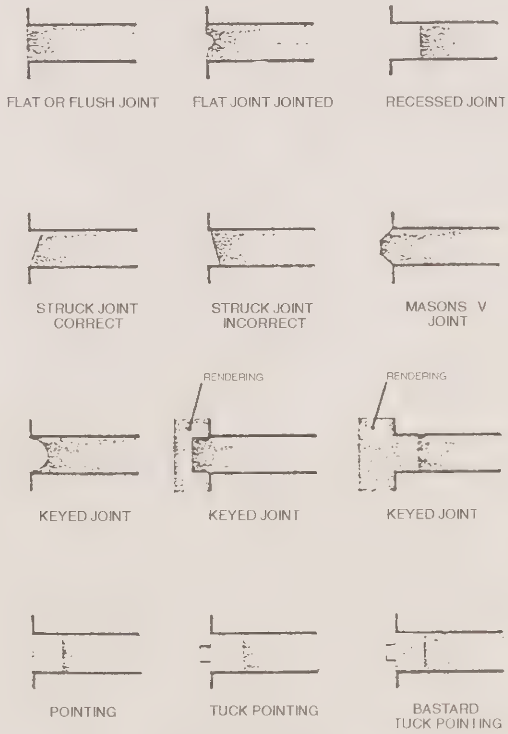
Bonding of Attached Piers – Examples of English and Flemish Bonds

3.3 JOINTING

The joints on the face of brickwork can be finished in a variety of ways. Some were described by Moxley by and Hodgson.

The joints may be finished as the work proceeds or on completion of the building. The former method is stronger and more durable. The latter is cleaner and has a better appearance, and is necessary when the work has been built during cold weather.

> Where the latter method is employed, the joints should be raked out for at least ½ inch as the work proceeds, all dust brushed away, and the brick and mortar surfaces well wetted immediately before pointing. The joints in new work should be clean, sharp, and regular (Moxley).



Various Types of Mortar Joints

3.4 FUNDAMENTAL SKILLS

The successful execution of plain brickwork depended on the fundamental skills of the bricklayer who had to be thoroughly familiar with the most effective ways of laying and splitting brick.

3.4.1 Laying Common Brick

The authors of the International Library of Technology (1898) textbooks recommended:

> Common brick should be laid in a bed of mortar at least $^3/_{16}$ and no more than $^3/_8$ of an inch thick. Every joint and space in the walls should be filled with mortar.
>
> The best way to allow for the thickness of the mortar joint is by the height of eight courses of brick, measured in the wall. This height should not exceed by more than 2 inches, the height of eight courses of the same brick laid dry. As common bricks are usually quite rough and uneven, it is not always easy to determine the thickness of a single joint, but the variations from the above rule, in any eight courses that may be selected, should be very slight.
>
> Pressed brick, being usually quite true and smooth, may be laid with a $^1/_8$ inch joint, though a $^3/_{16}$ inch joint is probably stronger, as it permits the use of more mortar, thus filling the joints better (International Library of Technology, pp. 102-3).

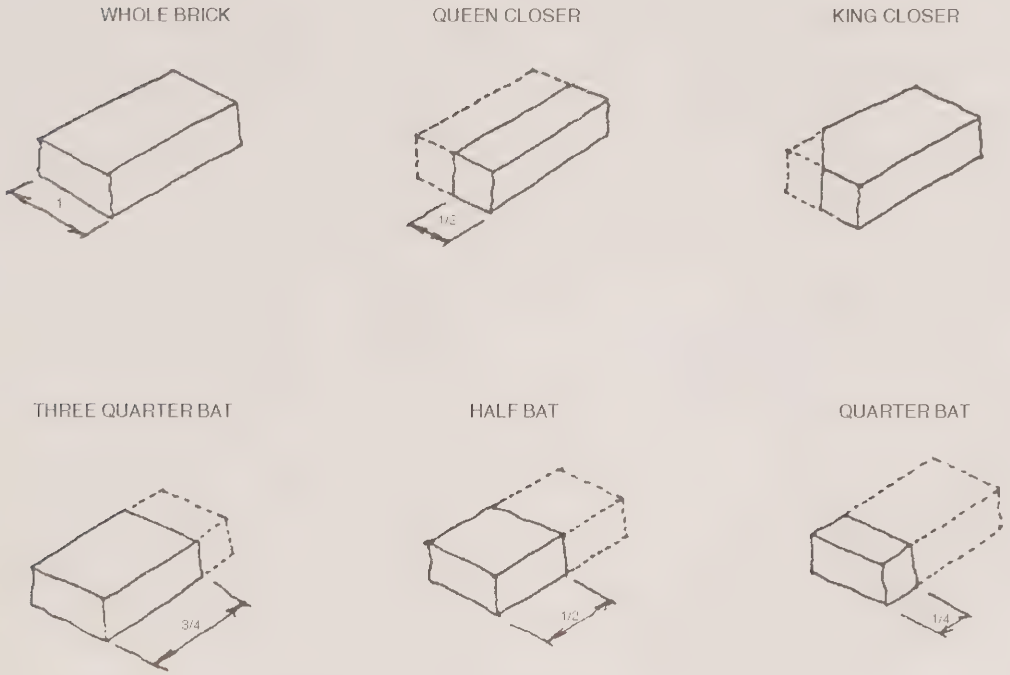
For laying walls, the same source recommended:

> The best method of building a brick wall is as follows: The two outside courses are laid first; the mortar is spread with a trowel, along the top of the last course of brick, to form a bed for the brick to lie on; next some of the mortar is scraped against the outer vertical edge of the last brick laid and then the brick to be laid is pressed into its place with a sliding motion, which forces the mortar to completely fill the joint. Having continued the inside and outside courses of brick to an angle or opening, the space between the brick should be filled with a bed of soft mortar and the bricks pressed into this mortar with a downward slanting motion, so as to press the mortar up into the joints; this method of laying is called shoving. If the mortar is not too stiff and is thrown into the space between the inner and outer courses of brick with some force, it will completely fill the upper part of the joints in the brickwork, which are not filled by the shoving process. A brick wall laid up in this way will be very strong and difficult to break down.
>
> Another method of laying in the brick between the inside and outside courses in a wall is to spread a bed of mortar and on this lay the dry brick. If the bricks are laid with open joints and thoroughly slushed up with mortar, it makes good work; but unless the workmen are carefully watched, the joints do not get filled with mortar and the wall will not be as strong as when the bricks are shoved.
>
> Some bricklayers lay the inside courses dry on a bed of mortar, as described in the previous paragraph and then fill all the joints full of very thin mortar. This is called grouting. No more mortar should be used than will fill all the joints. This method is not considered as good as those previously mentioned, because the mortar, being so thin, lacks cohesion and does not bind the brick together as well as the stiffer and more tenacious mortar. Grouting should never be done in freezing weather; the mortar contains so much water that it freezes very readily and is then useless as a bond (International Library of Technology, pp. 103-4).

3.4.2 Laying Pressed Brick

The following is a recommendation quoted from the International Library of Technology's brickwork manual:

> Face bricks are usually laid in mortar made of lime putty and very fine sand; often the mortar is stained with mineral pigments to match the colour of the brick. The joints should not exceed $^3/_{16}$ of an inch in thickness and, for very fine work, they are sometimes kept down to $^1/_8$ of an inch. The joints should be completely filled with mortar and either finished at once or raked out for pointing. In very particular work, such as laying pressed and enameled brick, a straightedge is held under the joint and a jointer run along on top of it, thus making a perfectly straight joint. This is called ruled work. Many masons prefer using a trowel (International Library of Technology, p. 104).



Typical Bats

3.4.3 Splitting Brick

Certain structural details required only smaller pieces of brick. These pieces were called bats and could be obtained by splitting the brick. Following is the method used for making crosswise and lengthwise cuts.

Crosswise cut:
In crosswise cuts, a cutting line was marked by pencil across the long side edges. The brick was then scored along that line with a broad-bladed chisel (brickset).

Lengthwise cut:
Before splitting brick lengthwise, a line all around the brick had to be marked. The surface of the brick was then scored along that line by tapping the line with the sharp edge of the square end of the bricklayer's hammer. After that, the brick was firmly held in one hand and struck sharply with the flat side of the square end of the hammer, just beyond the centre point of the scored line. A curved, chisel-like blade end of the hammer was used to clean off rough spots on the edges.

3.5 SEASONAL ADJUSTMENTS FOR BRICKLAYING

3.5.1 Brickwork During Frost

Bricklaying during frost requires caution and planning of facilities and equipment. Hodgson recommended:

> ... The bricks to be used for brickwork during frost shall be kept under cover free from moisture or frost. They are to be taken out only in small quantities as required for use, and are not to be wetted previous to being laid.
>
> ... The water, sand and lime for the mortar must similarly be kept under cover, free from frost. The lime is to be ground unslaked lime, mixed with the sand in the proportion of one part of lime to two parts of sand. Where the temperature is under 26° Fahr., the proportions shall be one part of lime to

> one part of sand. The mortar shall be mixed in ashes having a temperature of not less than 34° Fahr. in small quantities as required and used immediately.
>
> ... The brickwork is to be executed as rapidly as possible consistent with good workmanship, and the courses shall be immediately covered with sacking as the work proceeds.
>
> ... If the temperature shows less than 20° Fahr., the work shall be immediately stopped (Hodgson, pp. 177-78).

3.5.2 Brickwork in Hot Weather

The following measures are recommended for work in hot weather:

> When bricks are laid during warm weather, especially during hot and dry weather, they should be thoroughly wetted but not soaked to the saturation point just prior to the time they are laid. The wetting can be done with a hose or some form of water sprinkler which will just wet the bricks enough so that they look wet all over their surfaces (Dalzell and Townsend, p. 113).

3.6 PROTECTION AND CLEANING OF BRICKWORK

3.6.1 Protection

Brick walls are not usually designed to be free-standing. When freshly built, they could suffer damage from strong winds. To prevent such damage, bracing should be built to help the wall resist wind forces.

When leaving an unfinished wall, it is good practice to protect fresh mortar in the upper courses from being washed out by pouring rain. This is done by covering with plastic, straw mats, tar paper, etc.

3.6.2 Cleaning

The authors of *Cyclopedia of Architecture, Carpentry and Building* recommended:

> When a piece of brickwork is completed, the exterior will need to be cleaned of mortar stains and discoloration. This is done by washing down the wall with a dilute solution of muriatic acid, using a scrubbing brush, followed by washing with clear water to remove all traces of the acid. The wall is then often given a coat of linseed oil cut with turpentine.
>
> At this time also, all bad joints are pointed up, the spaces under window sills are filled up, the joints of stonework pointed and the wall left whole and clean (*Cyclopedia of Architecture, Carpentry and Building*, p. 116).

3.7 CONSTRUCTION

3.7.1 Footings

The laying of a "... footing 16 inches wide and approximately 8 inches thick..." has been described as follows:

> As soon as the subgrade is prepared, the bricklayer should place a bed of mortar about 1 inch thick on the subgrade to take up all irregularities. The first course of the foundation is laid on this bed of mortar. The other courses are then laid on this first course (U.S. Department of the Army, p. 150).

The same construction method is recommended for column footings.

3.7.2 Walls

The process of laying a brick wall can be divided into the following typical steps:

- laying out the wall
- laying corner leads
- laying the face tier between the corner leads
- laying the back tier.

This process is explained in detail in such contemporary sources as the U.S. Army's *Concrete, Masonry and Brickwork*, 1975.

Tables published in *Concrete, Masonry and Brickwork* can be consulted to arrive at the number of courses and horizontal joints required for a given wall height.

More details illustrating particular types of brick walls can be found below.

3.7.3 Piers and Buttresses

Piers in brickwork are rectangular pillars supporting loads transmitted to them by beams and girders or to receive the thrusts of two or more arches which fall in a vertical line.

They can be classified according to their construction as solid or hollow, according to their location as isolated or attached and according to their shape as straight or battered.

The techniques used in constructing piers is basically that used for brick walls.

Most bricklaying authorities recommended that piers were to be topped with a stone or cast-iron cap to permit their load to be equally distributed. To increase the strength of piers, the use of bond stones was also frequently recommended:

> In order to strengthen piers which are less than 3 feet square, bond stones are inserted at intervals which should not exceed 30 inches (*Building Stone Brickwork...*, p. 23).
>
> ....
>
> The ordinary proportion of bond stones are from 5 to 8 inches in thickness and the full size of the pier in cross-section spaced every 3 to 4 feet in height (Graham, p. 312).

The following reference recommended the type of stone for bond stones:

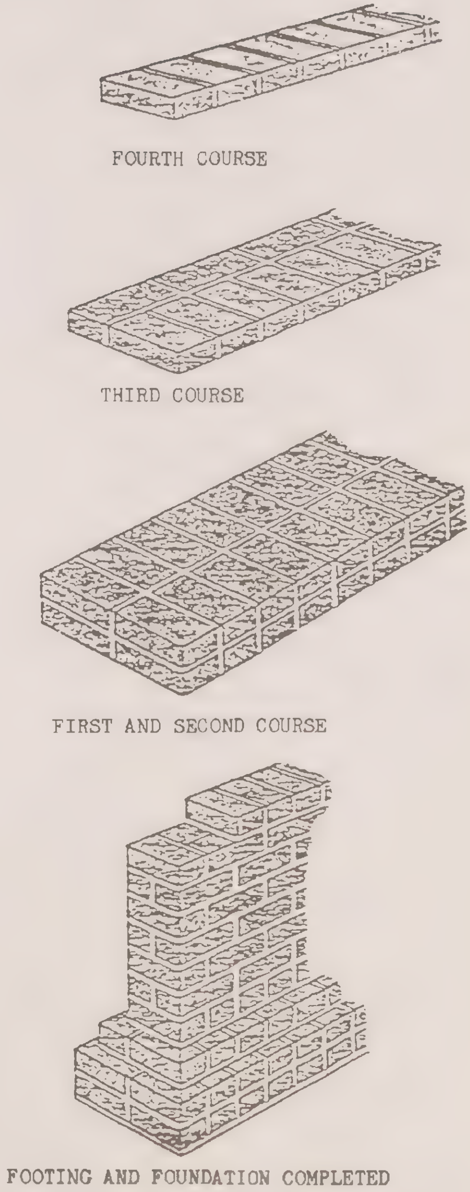
> The bond stones should be either granite, bluestone or one of the durable limestones. The blue Vermont marble is also used, but the softer sandstones and freestones should be avoided (International Library of Technology, p. 24).

The height of the piers was noted:

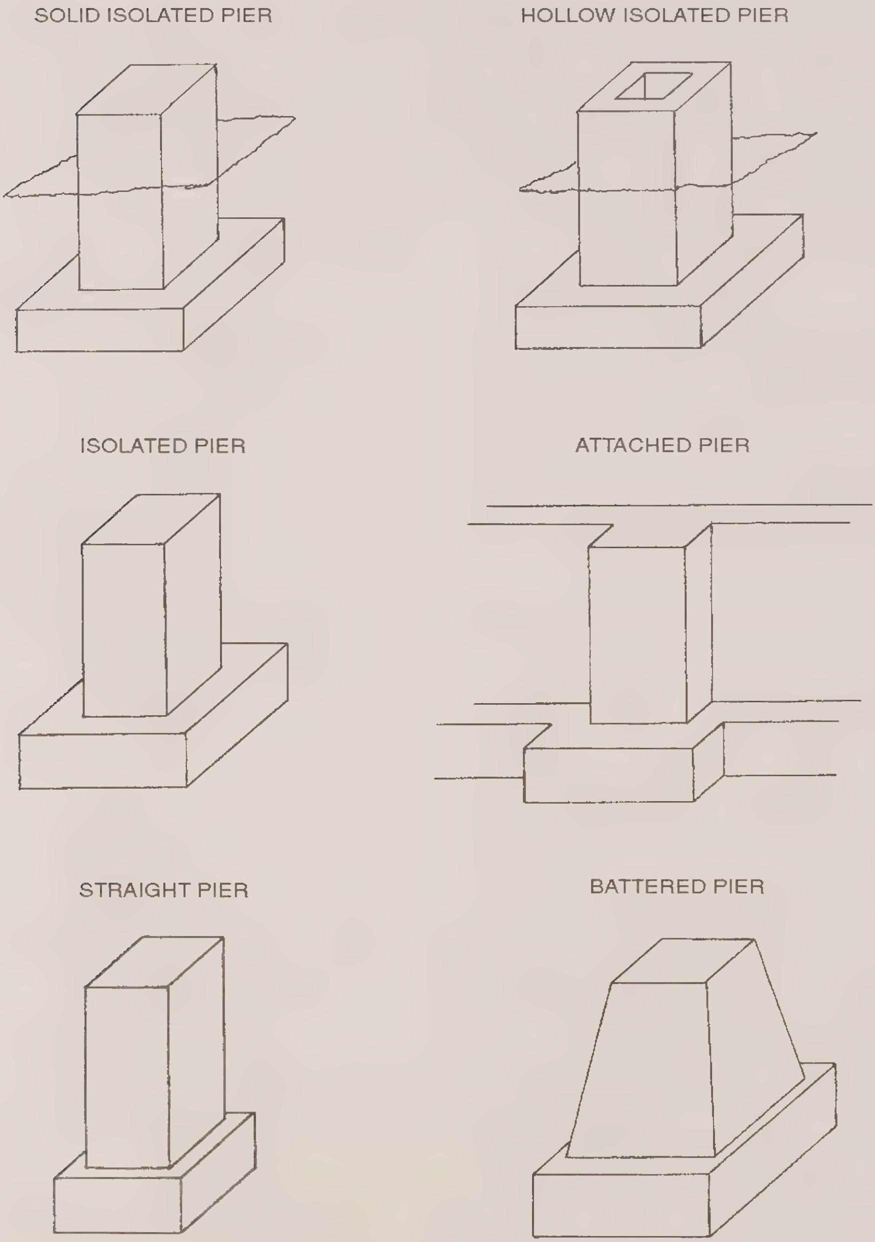
> No isolated pier should exceed in height 10 times its least transverse dimension (Graham, p. 312).
>
> ... that the height of isolated brick piers should not exceed 12 times their least square dimension (International Library of Technology, p. 23).
>
> The height of any isolated pier should not exceed 18 times its least dimension or have a width of less than 13 inches (Mitchell).

Attached piers were built to strengthen the walls at given intervals, the usual spacing being 3 or 3.6 metres (Mitchell).

No detailed description of buttress construction has yet been located.



Wall Footing (Concrete Masonry and Brickwork, p. 149)



Classes of Piers

3.8 PROVISIONS FOR WALL OPENINGS

Most modern writing on window and door openings focuses on the use of brick or concrete sills and steel or precast reinforced concrete lintels. Some of the descriptive material on the general planning and arrangement of brickwork around the openings, in contemporary sources such as *Concrete, Masonry and Brickwork*, can be assumed to represent period as well as contemporary practice.

4.0 CONSTRUCTION DETAILS

This section relies heavily on illustrations. It provides the reader with selected details on topics discussed in previous chapters.

4.1 WALLS

According to their construction, brick walls can be classified as solid, hollow and veneer. The first type was dealt with in some detail in 3.0 above. The latter are built according to the principles described below.

a. Hollow wall:
   The bricks of hollow walls are laid in the same manner as for solid wall.

   The wall consists of two portions tied together by common brick dipped in tar or brick made of vitrified pottery or cast-iron cramps and separated by a 65 mm air layer.

   The ties are placed horizontally, usually about one metre apart and with 230 mm vertical intervals between the rows.

b. Veneered wall:
   It has been common practice in residential construction to use brick veneer as a non-loadbearing siding or facing material over a wood frame.

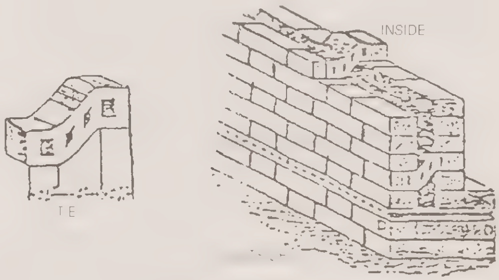
Pressed or face bricks, which are usually used for this type of work, are tied to the diagonal sheeting with metal ties. In late 19th-century residential work, cut nails were often used. The wire tie, known as the Morse tie, is commonly found. As well a tie made of No. 16 iron, 32 mm wide, with the end turned up, gives satisfactory results.

The ties should be placed on every other brick in every fifth course, as bricklaying progresses.

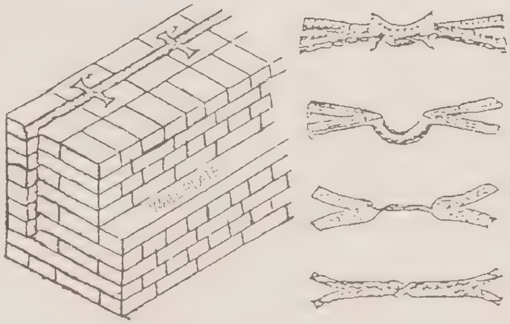
4.2 ANCHORING

Metal anchors of different shapes were used to strengthen the connection of intersection of two brick walls or for tying other structural elements such as beams or rafters to the wall. The following are comments on particular applications.

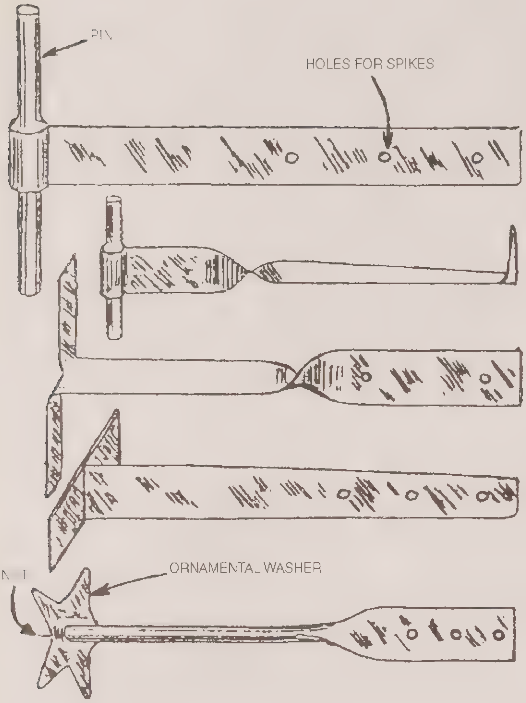
> Placement of anchors:
> An anchor should be placed at the center of a 4 inch recess or blocking. The T or pin anchor should be built into the center of the recess which should occur every thirteen courses. The anchor should project so as to give not less than 9 ins. of holding on the wall to be tied. These anchors should never be omitted when one wall is coursed up before the wall to be tied is built (Graham, p. 291).



Hollow Wall with Vitrified Brick Tie



Hollow Wall Tied Together with Metal Ties (anchors) and Examples of Metal Tie (anchor) Shapes



Variety of Anchor Shapes (Graham, p. 290)

Anchoring joists:
See correct and incorrect placement of anchors shown in illustration.

Anchoring roof-plates:
Before the top of the wall is reached, the anchors for bolting down the roof plate should be placed and the brickwork carried up around. The anchors should be made of half-inch bolts, at least 12 inches long, with a tee or washer at the bottom and a nut and washer at the top. They should be set approximately every 6 feet along the wall (Graham, p. 299).

4.3 DAMPPROOFING

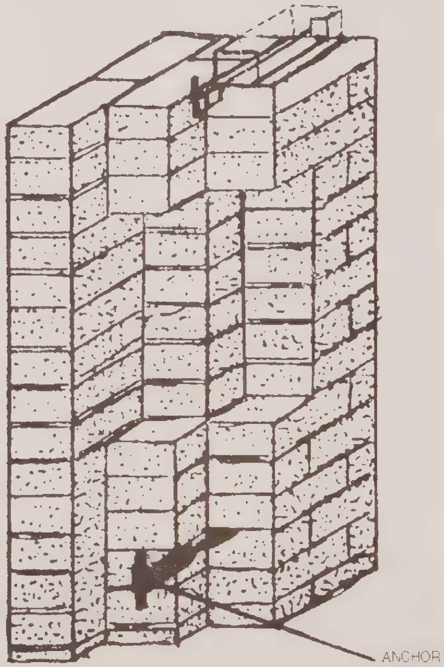
Following is a description and illustration of some measures which prevent dampness in walls.

a. Horizontal damp-proof courses:
The damp-proof course should be 6 inches or more above the level of the external ground, but under the wall plate carrying the floor joists (Burrell, p. 83).

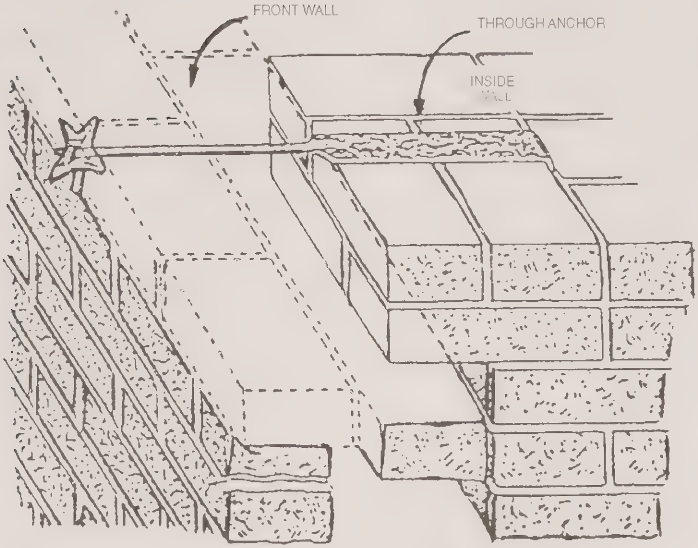
The materials forming damp-proof courses included asphalted felt, slates set in cement or very good, but expensive, lead.

b. Vertical damp-proof courses:
The wet may be kept out of the interior of the wall by rendering the exterior surface with cement, covering it with slates fixed on battens or with glazed tiles set in cement (Burrell, p. 83).

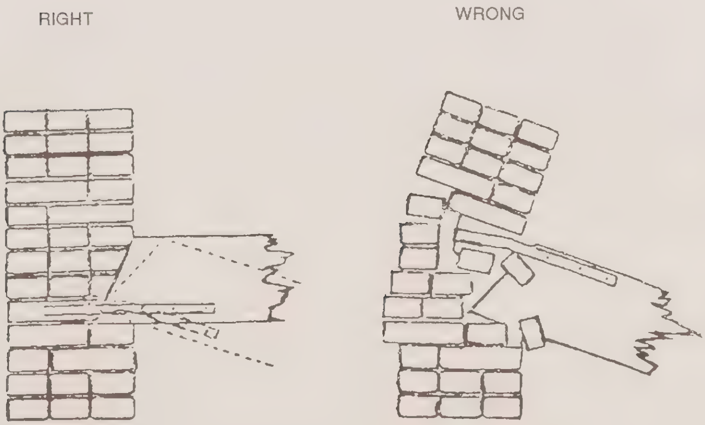
... a coating of asphalt applied while boiling hot, thoroughly covering the brickwork, is very satisfactory (Graham, p. 306).



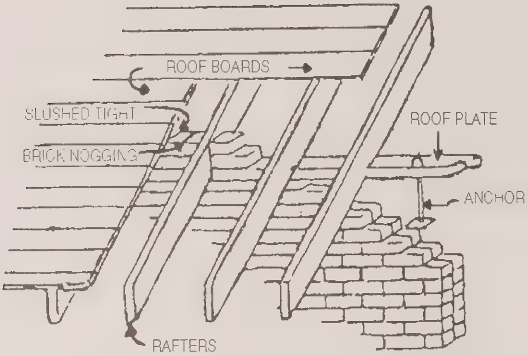
End of 305 mm Side Wall Showing Anchors Built in and "Teeth" for Tying Front (Graham, p. 292)



Intersection of front and inside wall showing placement of through anchor (Audels, P. 293).



Example of right and wrong placement of anchors on joists (Audels, P. 294).



Method of Anchoring Roof Plate Showing Rafters and Roof Boards in Place
(Graham, p. 300)

c. Copings:
Penetration of water through the top of brick walls was usually prevented by copings. They were made from materials such as stone, copper or sheet metal, terra cotta tiles, slates, brick or cement, in a variety of shapes.

d. Air drains:
These are narrow dry areas, 230 mm or more in width, formed around parts of walls which are below ground.

Bricklaying technique for construction of air drains was the same as that applied for any other solid brick wall.

e. Flashing:
Flashing prevents rainwater from entering walls at parapets, sills, projections, recesses, roof intersections, etc.

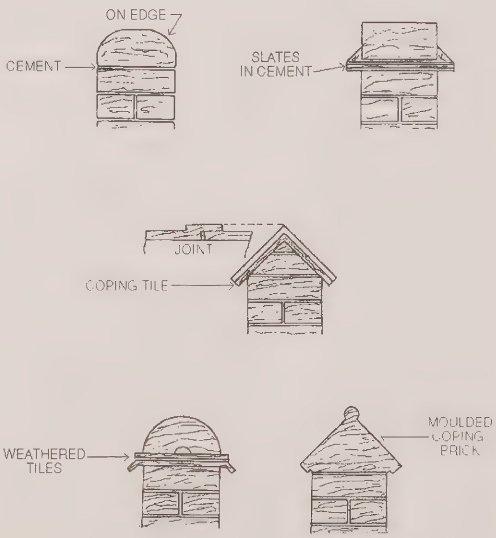
Typical materials for flashings were lead, zinc or copper.

f. Weepholes:
They should be provided immediately above all flashings or other water stops to drain away any accumulated water. The holes were usually located in the head joints of the outer wythe and spaced about 610 mm apart (Hodgson). In no case should weepholes be located below grade. They should also be small enough to keep out rodents.

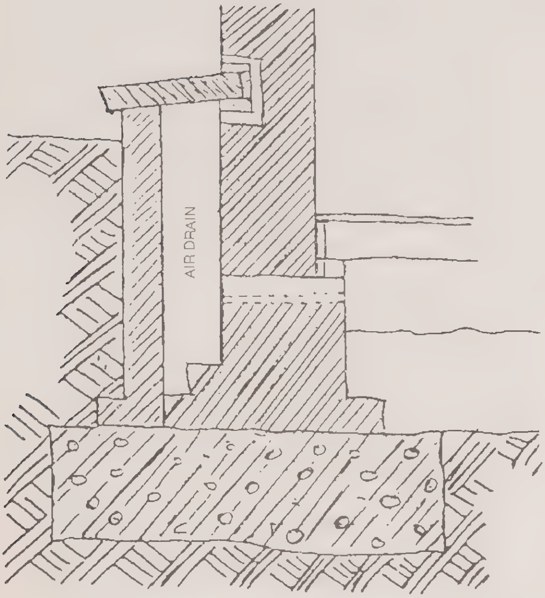
5.0 GENERAL SPECIFICATION CLAUSES

General specification clauses concerning bricklaying can be found in a number of technical publications. For this article, the major source of information was a publication by a Canadian author in 1905. It provided comprehensive information which represents knowledge and experience of the history of bricklaying. Information on materials, workmanship and brickwork during the frost is presented in the form of quotes.

General specification clauses specify building materials, workmanship and other requirements of the construction process. Blank spaces are left in areas describing quantities of required materials of work. After filling in the missing data, the builder could use the clauses for ordering materials, job specifications, etc.



Typical Examples of Copings



Examples of Typical Air Drain

5.1 MATERIALS

5.1.1 Bricks

1. All bricks intended for use under this Specification must be the best of their respective kinds, hard, square, sound, well-burnt and even in size. No brick must absorb more than one-sixth of its dry weight in water during one day's immersion. Samples of each kind, selected at random from the load, must be deposited with and approved by the architect before any of that particular kind are laid.

• • • •

All bricks shall be carefully handed from the carts and stacked and no broken bricks or bats are to be brought upon the ground.

2. All hard, sound, clean and approved old bricks, obtained from pulling down the old buildings on site, may be re-used where directed.

3. The stock bricks are to be obtained from........ *or* (equal to the manufacture of........) similar in all respects to the samples deposited with the architect.

4. The stock bricks for facings are to be carefully selected for their evenness of color and face and the visible arrises must be undamaged.

5. The pressed (red) facing bricks are to be (obtained from........) *or* (equal to the manufacture of........) similar in all respects to the samples deposited with the architect. In all cases the visible arrises must be undamaged.

6. The hard, wire-cut gault bricks are to be (obtained from........) *or* (to be equal to the manufacture of........) similar in all respects to the samples approved by the architect.

7. The cutters or rubbers are to be obtained from........ or other approved manufacturer, equal in quality, free from all lumps and flaws and similar in all respects to those approved by the architect.

8. The salt-glazed facing bricks must be slip-glazed and are to be obtained from........ or other approved manufacturer. They must be fairly uniform in tint and equal in all respects to samples approved by the architect.

9. The salt-glazed bricks are to be obtained from........ or other approved manufacturer, fairly uniform in tint and equal in all respects to samples approved by the architect.

10. Reveals, arches, projecting piers, etc., in salt-glazed work are to have bull-nosed angles. Any squints, etc., to be in salt-glazed quoins to required angle.

11. The enamel-glazed bricks are to be obtained from........ or other approved manufacturer. Samples of the required color or colors must be deposited with and approved by the architect before any of this work is executed. Provide enamel-glazed bull-nosed angle bricks for reveals and arches to windows and doors, projecting doors, etc. Provide all enamel-glazed quoins to required angles for squints, etc.

12. The firebricks are to be obtained from........ or other approved maker (raw and unburnt) *or* (thoroughly burnt and vitrified), and equal in all respects to the samples approved by the architect.

13. The smoke flue pipes (with air flues combined) are to be of the best fireclay, and of approved stock pattern, to be obtained from........ and equal to the samples approved by the architect.

14. The moulded strings, stops, cornices, angles, sills, jambs, plinths, panels and keys, etc., shown on details, are to be obtained from the same manufacturer supplying the facing bricks, and of similar make, equal in all respects to the samples approved by the architect.

15. The coping bricks are to be (as per detail drawing) *or* (of approved stock pattern), from........ *or* other approved maker..... inch by..... inch straight, and even colored and all arrises and angles must be perfect.

16. The bonding bricks for hollow walls are to be obtained from........, of improved bent pattern, equal to samples approved by the architect and of the following size: Lower flange,..... inch; middle flange,..... inch; upper flange,..... inch.

17. The........ bricks for the ($4^1/_2$-inch groined arch work) are to be made by........ or other approved maker, each brick cut to the proper size and radius as shown on the detailed drawing and marked before it leaves the works with a number corresponding to that on the drawing showing its proper position in the arch (Hodgson, pp. 164-66).

5.1.2 Sand

18. To be clean, sharp, pit or fresh-water sand, coarse grained, and of approved quality. To be entirely free from loam, clay, dust, or organic matter. If directed it must be washed, when used with cement.

19. If the lime mortar is mixed in a mortar mill, the architect, at his discretion, may allow the contractor to substitute a certain proportion of clean, hard brick, hard burnt ballast, or other approved material in lieu of sand. Such permission shall be given in writing, and shall clearly state the exact proportion of the substitute material which the contractor will be allowed to use (Hodgson, p. 166).

5.1.3 Water

20. The whole of the water required for the works must be perfectly fresh and clean and free from any chemical or organic taint (Hodgson, p. 166).

5.1.4 Lime Mortar

21. The limes for mortar shall be the best of their respective kinds, obtained from (manufacturers approved by the architect) (the firms hereinafter specified) and shall be fresh burnt (and ground) when brought on the… works.

22. The lime shall be thoroughly slaked at the scene of operations by the addition of sufficient water. During the process it shall be effectually covered over with sand to keep in the heat and moisture. All lime must be used within ten days of slaking.

23. The contractor shall, at his own expense, provide a proper mortar mill, worked by steam or other approved power for the due incorporation of the materials and all expenses in connection therewith shall be defrayed by the contractor.

24. If a mortar mill is not provided for the making of the mortar, the contractor will be required to thoroughly screen the materials before mixing to get rid of any dangerous and refractory lumps.

25. A proper stage is to be provided to receive the lime mortar, when made. The mortar in no case to be deposited on the ground.

26. The materials for all lime mortars are to be measured in the proper stated proportions, in quantities sufficient only for each day's requirements.

27. Fat lime mortar must not under any circumstances be used for the purposes of the specification.

28. The stone lime mortar for brickwork above ground level shall be composed of one part of gray lime (obtained from....) and two (three) parts of sand, mixed with a sufficiency of water and thoroughly incorporated together.... in their dry state before being put into the mortar mill.

29. The lias lime mortar shall be composed of one part of blue lias lime (obtained from....) and one part of sand, mixed with a sufficiency of water and thoroughly incorporated together (in a mortar mill). (The lias lime mortar for brickwork above ground level shall be made in the same manner, but in the proportions of one part of lime to two parts of the sand). (The lime and sand in their dry state shall be mixed together on a proper stage before being put into the mortar mill).

30. The blue mortar shall be composed of three parts of fine foundry ashes, two parts of ground stone lime and two parts of sand (Hodgson, pp. 166-67).

5.1.5 Cement Mortar

31. A proper stage is to be provided for mixing Portland and Roman cement mortar upon and the water must be added from a can with a fine rose.

32. No cement mortar that has become partially set shall be revived or re-used.

33. The Portland cement shall be obtained from..... (an approved maker) and shall be of the best quality composed entirely of thoroughly well burnt clinker ground fine enough to pass a sieve of 2500 meshes to the square inch, without leaving more than 10 per cent behind. The cement shall not contain more than 1 per cent of magnesia and 63 per cent of lime. It shall weigh not less than 112 lb. per striked imperial bushel when lightly filled into the measure from an inclined trough placed 12 in. above the top of the measure.

Test briquettes made of the cement, mixed with 18 per cent by weight of water, shall be capable of maintaining – after seven days' immersion in water – a tensile strain of 350 lb. per square inch the immersion to commence within twenty-four hours of the briquettes being made. The temperature of the atmosphere and water in which the test briquettes are made shall not be less than 40° Fahr. The tensile strain shall be applied at the rate of about 400 lb. per minute.

Samples of the cement when made into a paste with water and filled into a glass bottle or test-tube must not in setting become loose by shrinking from the sides or crack the vessel.

34. The cement shall be emptied and spread upon the dry wooden floor of a covered shed to a depth not exceeding 2 ft. for a period of not less than 14 days (or such other period as may be considered necessary) and shall be turned over from time to time as may be directed by the architect.

35. The cement shall be delivered on the works in such quantities as to allow sufficient time for testing before being required for use and the contractor shall be entirely responsible for any delay or expense caused by the rejection of cement which does not satisfy the special requirements.

36. The Portland cement mortar shall be composed of one part of Portland cement to two parts (one part) of sand, mixed together, turned over and thoroughly incorporated with a sufficiency of water. It is to be made in small quantities from time to time as required, and must be used within one hour of mixing.

37. The Roman cement is to be of the very best quality and obtained from an approved manufacturer. The raw stone shall be fine grained and after being thoroughly burnt, shall be ground to a fine powder. The finished cement must not weigh more than 70 lb. per trade bushel or more than 32 kg per trade bushel and must be stored in airtight drums or casks and kept in a dry place in free air currents.

38. The Roman cement mortar shall be composed of one part of Roman cement and one part of sand, mixed together with a sufficiency of water and thoroughly compounded. Owing to the quick-setting property of the cement, the mortar must be mixed by an experienced workman close to the position at which it is required and used immediately. When once partially set, it must not be revived.

39. The selenitic cement is to be obtained from the patentees, and mixed and used in accordance with the printed instructions issued by them.

40. The fireclay is to be of the best quality and from the same manufacturer supplying the firebricks (Hodgson, p. 169).

5.1.6 Stoneware for Damp-proof Courses

41. The damp course is to be formed with stoneware (fireclay) perforated vitrified blocks.... in. by.... in. and of the several widths required for the respective walls. The blocks are to have ribbed surfaces and tongue and grooved joints.

42. The bituminous sheet damp course is to be obtained from........ and laid (in accordance with their instructions) by them (the contractor given due and reasonable notice, as arranged, when the walls are ready, so that there may be no delay) [Hodgson, p. 169].

5.2 WORKMANSHIP CLAUSES FOR GENERAL WORK

5.2.1 Preliminary Clauses

43. All brickwork is to be set out and built of the respective dimensions, thicknesses and heights shown on the drawings.

44. All bricks are to be well wetted before being laid. The tops of the walls where left off are to be well wetted before recommencing them, as often as the architect may deem necessary.

45. All joints are to be thoroughly flushed up as the work proceeds. The vertical joints in the heading courses of English bond are to receive special attention.

46. Carry up walls in a uniform manner, no one portion being raised more than 3 ft. above another at one time. All perpends, quoins, etc., to be kept strictly true and square and the whole properly bonded together and levelled round at each floor.

47. No brickwork is to be carried on during frosty weather, unless with the written permission of the architect who will give special directions as to the manner in which the work is to be performed. All brickwork laid during the day shall (in seasons liable to frost) be properly covered up at night with felt, sacking, boards or other approved non-conducting material. Should any brickwork, laid on the day previous to a frost, become affected or damaged through not being covered or properly protected as previously specified or by reason of the exceptional severity of the weather, the architect, at his discretion, may require the whole or any part of such brickwork to be removed and reinstated by the contractor at his own expense (Hodgson, pp. 169, 170).

5.2.2 Bond

48. Brickwork generally except facings (all brickwork) to be laid in English bond consisting of alternate courses of headers and stretchers. Snap headers will not be permitted and bats only as closers.

49. All facings are to be executed in Flemish bond, consisting in each course of headers and stretchers alternately, to break joint accurately.

50. Cut indents in alternate courses of existing brickwork and tooth and bond new brickwork to same in cement mortar.

51. Lay in walls, at intervals of four courses, a layer of $1^1/_2$ in. stabbed hoop-iron to each $4^1/_2$ in. of thickness of wall, lapped or hooked at all angles (Hodgson, p. 170).

5.2.3 Joints and Pointing

52. The height of four courses of bricks laid in mortar is not to exceed by more than one in. the height of the same bricks laid dry.

53. The exterior facings are to be pointed with a neat weather joint in cement (blue mortar) cut in top and bottom, a sample of which is to be approved.

54. The interior facings to cellars are to be pointed with a flush joint neatly struck with the point of the trowel.

55. The joints to gauged work are to be pointed with........ (lime putty) (cement mortar).

56. The enamel and salt-glazed facings to be flush pointed in Parian cement, tinted to color of the glaze, the white enamel-glazed facings to be flush pointed in Keen's cement.

57. All internal walls, excepting those otherwise described, to be left rough for plaster.

58. Rake out joints for and point all flashings in cement and also all frames (Hodgson, pp. 170, 171).

5.2.4 Footings and Piers

59. Footings to be formed to spread on each side of the walls, half the respective thickness of same at base, diminishing in regular $2^1/_4$ ft. offsets to proper thickness of walls. The course of footings are to be laid of headers where practicable.

60. All underpinning to be executed with approved hard bricks, laid in cement mortar, well grouted at every course and carefully wedged up with slate, provided by the contractor.

61. Lay over the full thickness of all walls and piers at the levels shown on drawings the........ horizontal damp course.

62. The outside faces of vaults, walls, dry areas to have approved asphalt damp course, $^1/_2$ in. thick, laid thereon from the level of horizontal damp course to top of walls and continued over top of vaults and turned up around coal or ventilating plates or pavement lights, as required, to make vaults thoroughly water-tight.

63. All isolated piers carrying weights and elsewhere if described, to be built in pressed bricks laid in cement and grouted at every fourth course.

64. Build honeycomb (solid) fender walls on proper footings to ground floors where shown.

65. (a) Build up dry area wall as shown on drawings in cement mortar, arched over into main wall three inches below ground level.

(b) Build up dry area wall as shown on drawings in cement mortar. Bed and point stone cover (provided by "mason"), as shown, in cement mortar (Hodgson, p. 171).

5.2.5 Walls in General

66. Build in or cut, bed and pin in, all sills, thresholds, steps, landings, corvels, ends of joists, etc., in cement and point as required. Build in frames, bedded solid in reveals, where specified to be built in.

67. Brickwork to be well pinned and backed up to all stonework and terra-cotta and cut and fitted to ends of all steel joists, girders, lintels, etc.

68. Build in brickwork where required, fixing blocks (provided by "concretor") for fixing carpenters' or other work.

69. Build half-brick walls, small piers between windows and elsewhere as directed, in cement mortar.

70. Build chases and reveals in walls to receive frames, pipes, light wiring, etc., as shown on drawings or required.

71. Bed all plates, lintels, templates, cover stones, etc., in cement as required.

72. Neatly cut and fit all facings to stone or terracotta dressings, arches, etc. and execute all rough and fair cutting as required.

73. Leave horizontal chases in walls to receive concrete floors or build sailing courses as shown to support same.

74. Turn rough segmental relieving arches in cement over all lintels where practicable.

75. Oversail where possible to support concrete floors and projections and to receive plates.

76. Level up on top of all riveted girders with plain tiles and cement.

77. Build in........ air bricks (provided by "terra-cotta and Faience worker") ("founder"), where shown on drawings and form cranked air-ducts to them in the wall, rendered in cement and sand.

78. The panels intended for carving are to be executed in rubber brick, as shown on drawings, set in shellac.

79. All niches, panels and other enrichments to be executed in........ as shown on drawings (Hodgson, pp. 171, 172).

5.2.6 Sundries

98. Build $4^1/_2$ in. (glazed brick) piers (in scullery), where shown on drawings, to support stoneware (stone) sink and properly bed and point same in cement mortar.

99. Cope parapets where shown to have brick coping, with two courses of plain tiles bedded in cement to project $1^1/_2$ in. from faces of wall or........ patent drip tiles and brick on edge coping the thickness of wall bedded and pointed in cement mortar and ramped as required.

100. Cope parapets and other walls where shown with purpose made coping bricks the thickness of the wall, pattern No......'s list, bedded and pointed in cement mortar.

101. Bed and point stone copings, provided by "mason", in cement mortar with the joints joggled.

102. Cut and pin in ventilating flues where shown approved ventilators, provided by "ventilating engineer."

103. The contractor shall, before pointing, clean down all brick facings and make good all putlog and other holes throughout the work as it proceeds and point the same.

104. Cut away, etc., as required for other trades and make good after same (Hodgson, p. 174).

5.2.7 Hollow Walls

105. Build up the hollow walls as shown on drawings in two thicknesses, the outer thickness to be $4\,^1/_2$ in., the inner..... in., with a $2\,^1/_2$ in. cavity between, the thickness of the entire wall being..... in. Bond the two thicknesses together with..... wall ties placed at a distance apart of 3 ft. horizontally and 12 in. vertically. The cavity is to be kept clear of all rubbish or mortar droppings by movable boards or other means. Leave openings at the base and clean out the cavity at completion, the openings afterwards to be bricked up uniform with surrounding work. The wall ties to be carefully laid and in no case to fall towards the inner thickness of the wall. Build into inner face of exterior thickness over all frames a piece of sheet lead, provided by "plumber", projecting 2 in. beyond each side of lintel and turned up $1^1/_2$ in. (Hodgson, pp. 174, 175).

5.2.8 Damp-proof Walling

106. Build up the walls in two thicknesses, the outer thickness being $4^1/_2$ in., the inner thickness..... in., with a $^1/_2$ in., cavity between, the total thickness of the wall being..... in. The bricklayer is to leave the cavity face joints free of mortar for a depth of $^1/_2$ in., the cavity being kept clear of mortar droppings with a movable plain board. At a height of every four courses fill up the cavity with........ building composition, prepared and used according to instructions (Hodgson, p. 175).

5.2.9 Retaining Walls

107. The retaining wall to be carried up according to the detail drawing, to be built of..... bricks laid in cement mortar grouted at every fourth course, to have the exterior face battered, the inner face finished with (diminishing offsets) all as shown.

108. Build in where shown 3 in. and drain pipes to run through the entire thickness of the wall, cut bricks to fit and make good around same in cement mortar (Hodgson, p. 175).

5.3 BRICKWORK DURING FROST

122. The bricks to be used for brickwork during frost shall be kept under cover free from moisture or frost. They are to be taken out only in small quantities as required for use and are not to be wetted previous to being laid.

123. The water, sand and lime for the mortar must similarly be kept under cover, free from frost. The lime is to be ground unslaked lime, mixed with the sand in the proportion of one part of lime to two parts of sand. Where the temperature is under 26°Fahr. the proportions shall be one part of lime to one part of sand. The mortar shall be mixed in ashes having a temperature of not less than 34°Fahr. in small quantities as required for use immediately.

124. The brickwork is to be executed as rapidly as possible consistent with good workmanship and the courses shall be immediately covered with sacking as the work proceeds.

125. If the temperature shows... less than 20°Fahr., the work shall be immediately stopped (Hodgson, p. 178).

6.0 BIBLIOGRAPHY

American School of Correspondence. 1907. *Cyclopedia of Architecture, Carpentry and Building.* Staff of Architects, Builders and Experts. Chicago.

Anon. 1901. *Canadian Contractors' Handbook and Estimator.* The C.H. Mortimer Publishing Co., Toronto.

Burrell, E.J. 1893. *Advanced Building Construction, A Manual for Students.* Longmans, Greene & Co., New York.

Dalzell, Ralph J., and Gilbert Townsend. 1957. *Bricklaying Skill and Practice.* Revised edition. American Technical Society, Chicago.

Fowler, William H. 1903. *Fowler's Architects', Builders' & Contractors' Pocket Book.* 1st edition. Scientific Publishing Company, Manchester.

Frost, William. 1933. *The Bonding of Brickwork.* Cambridge at the University Press, Cambridge.

Graham, Frank D. 1926. *Audels Masons and Builders Guide No. 2.* Theo Audel & Co., New York.

Hodgson, Fred T. 1905. *20th Century Bricklayer's and Mason's Assistant.* Frederick J. Drake and Co., Chicago.

International Library of Technology. 1898. *Building Stone, Lathing, Plastering, and Tiling; Common Brickwork, Ornamental Brickwork and Terra-Cotta; Lighting Fixtures; Architectural Design.* International Textbook Company. Scranton, PA.

Macey, Frank W. 1922. *Specifications in Detail.* Crosby Lockwood and Son, Ludgate Hill, London.

McKee, Harley, J. 1973. *Introduction to Early American Masonry, Stone, Brick, Mortar and Plaster.* National Trust for Historic Preservation and Columbia University, Washington, DC. Quoted material and illustrations reprinted by permission: Copyright 1973, National Trust for Historic Preservation in the United States.

Moxley, Ramond. 1961. *Mitchell's Building Construction, Elementary Course.* B.T. Batsford, London.

Randell, Frank A., Jr., and William C. Ravarese. 1976. *Concrete Masonry Handbook for Architects, Engineers, Builders.* Portland Cement Association.

Sutcliffe, G. Lister. 1899. *The Principles and Practice of Modern House Construction.* Vol. 1. Blackie and Son, London.

U.S. Department of the Army. 1975. *Concrete, Masonry and Brickwork.* Dover Publications, Inc., New York.

Illustrations are property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

5.2
PERIOD BRICKLAYING AND TILING
TERRA COTTA AND TILE WORK

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: D. BOUSE/G. SHEMDIN

CONTENTS

1.0 INTRODUCTION

Terra cotta (literally "baked earth") is another early building material common in ancient Egypt and Greece, and in Rome where it was used as a substitute for stone. Little used after Roman times, it was revived in Europe during the Renaissance, particularly in Italy where "it was used ... to create some of the best architectural ornament and relief sculpture ever made" (McKee, p. 54). Its use declined until the early 19th century in England where it became increasingly popular – it was considered very compatible with brick construction which at that time was replacing timber and stone.

Photo courtesy of CIHB

139 Cordova St. East, Vancouver, BC

In America several attempts were made in the mid-19th century to establish the manufacture and use of terra cotta that met with little success and actually with a good deal of resistance from stone cutters who questioned its durability. However in 1871 when the architects Sturgis and Brigham elected to import it for the prestigious Museum of Fine Arts in Boston, it was accepted and its desirability established.

Terra cotta was extensively used for rebuilding Chicago following the fire of 1871 and for several important buildings in the early 20th century, such as the Woolworth Building (1913) in New York City and the Wrigley Building (1921) in Chicago. The popularity of terra cotta grew because it was fireproof; therefore, it could also serve well on the iron and steel framed buildings being erected in increasing numbers. It was also regarded as an excellent stone substitute for ornamental details.

Its success in both capacities is well exemplified in Louis Sullivan's Wainwright Building in St. Louis, built in 1890 and the 1894 Guaranty Building in Buffalo, or the white terra cotta sheathed Carson-Pirie-Scott store in Chicago built in 1904. Fine as these designs are, we are reminded that "they would hardly have reached reality without the prior development of a terra-cotta industry in America for the production of the material, or continuous experiment to perfect the relatively sophisticated technology of its application" (Floyd, p. 102).

After achieving a height of popularity around the turn of the century, terra cotta had declined by the 1930s. Some early installations had failed, causing a loss of confidence in the product. Also by that time it was being replaced by newer, less labour-intensive and therefore less expensive materials.

2.0 MANUFACTURE

Architectural terra cotta was made from a carefully worked, fine grained clay which was hand tamped into a plaster mould. After removal from the mould, the blocks or panels were dried by steam heat and glazed, either with a "slip" – a thin clay brushed or sprayed on – or with a salt glaze. After firing and cooling, the blocks were trimmed if necessary and numbered for assembly in a predetermined pattern. Ornamental panels could also be produced in a steel mould using the same dry press method used for bricks.

Prior to about 1890 most terra cotta was produced only in its natural rust colour; later yellow and buff became favourite

shades. In turn, these colours were superseded by white and then a variety of tones.

The colour was specified and the designs carefully worked out by the architect for facing blocks and ornamental detail. In addition, some tile companies employed their own designers for the small decorative panels that were much in demand as accents on brick faced buildings.

Terra cotta veneer was either built into the wall – in which case the blocks were back-filled – or secured with metal anchors of various designs.

3.0 CLAY TILE

About 1900 as the demand for brick fell off – it was now being used as a veneer rather than as a structural wall material – there was an increased demand for clay tile for fireproofing the newer iron and steel framing, for flat arched floors and for interior partitions.

Suitable clay tiles were made like brick, of a stiff mix extruded in a hollow core design. Similarly they were then dried and fired. They could be smooth surfaced, scored or finished with a salt glaze and were produced in a variety of sizes.

By adding sawdust to the clay mix, a porous texture could be obtained. The sawdust burned out in the firing process. The resulting tile could be nailed like wood and was marketed as terra cotta lumber. Produced in both Toronto and Montréal, it was used in several major buildings of the early 20th century (see Ritchie).

Another clay-based moulded product used for ornamental work was Coade stone. Developed in England in 1769, it was a popular substitute for carved stone until the closing of the originating company in 1840 (see Derry and Williams). Known imports in Canada were the statue on the Nelson Monument (1804) in Montréal and the decorative plaques on the Bank of Montreal (1819), all of which were made by the Coade Company in London (see LaFrance).

Photo by Maria Subercaseaux

The Bay – Ste. Catherine Street, Montréal, PQ (Terra Cotta)

3.1 CLAY TILE (SURFACE WORK)

In Europe, during the 17th and 18th centuries, clay tile became popular for its fireproofing and decorative qualities. It was used particularly for fireplace surrounds and for chimney and stove areas.

In the United States and Canada the use of tiles on interior wall surfacing and flooring was noted towards the end of the 19th century. It has grown in popularity, especially for walls, to the present day.

Most tiles today are machine pressed and vitrified, whereas previously they had been hand cast. Usually produced in small squares, tiles can be any shape and any colour desired (in fact, few building materials can equal the range and durability of the colours created by the glaze on terra cotta). The colour can be mixed with the clay before firing (encaustic) or can be added in the glaze (ceramic). Often a design is added to the tile – the surface is flat and the final finish is glossy or matte. The matte finish and retention of the natural rust tone of the clay distinguishes quarry tile from ceramic, although the basic manufacturing method is the same.

Quarry tiles are used for flooring – commonly for fireplace hearths, vestibules and commercial kitchens; ceramic tiles are almost always used in areas where sanitation is important and usage is high, such as washrooms and kitchens (both domestic and commercial).

4.0 TERRA COTTA IN CANADA

Prior to the 1880s, terra cotta was imported from the United States, usually in the form of small, carved plaques. However, by then the demand in Canada for terra cotta ornament had increased sufficiently to make its production a viable industry. At least three companies – all in the Toronto area – were involved in its manufacture: the *Toronto Pressed Brick and Terra Cotta Company* near Milton, the *Ontario Terra Cotta and Pressed Brick Company*, west of Toronto and the *Don Valley Brick Works.*

Terra cotta is known to have been used on several "major" buildings of the late 19th and early 20th centuries such as the Confederation Life Building in Toronto (1890), the Birks Building in Winnipeg (1901), the Dominion Building in Vancouver (1908) and the Electric Railway Chambers built in Winnipeg (1913), indicating contemporary popularity. Although there have been dozens of articles written and very extensive bibliographies compiled on the manufacture and use of terra cotta in the United States and Britain, there appears to be very little researched information on the manufacture or use of terra cotta in Canada.

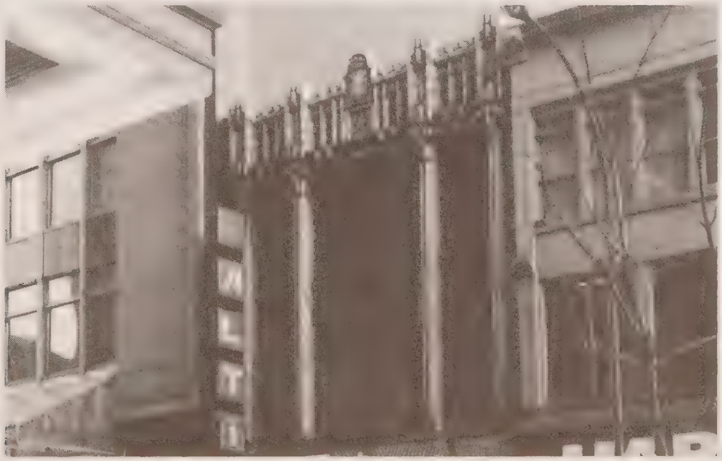


Photo by Maria Subercaseaux

Terra cotta detail – Magasin Jaeger 1914. 682 Ste. Catherine, Montréal, PQ

5.0 BIBLIOGRAPHY

Association for Preservation Technology, Bulletin of the. 1977. Vol. 9, No. 1, pp. 32-73. Ottawa.

Derry, T. K., and Trevor I. Williams. 1960. *A Short History of Technology.* Oxford University Press, Oxford.

Floyd, Margaret H. 1973. "A Terra-Cotta Cornerstone for Copley Square," *Journal of the Society of Architectural Historians,* Vol. 32, No. 2. Philadelphia. Quoted material is reprinted by permission: Journal of the Society of Architectural Historians.

Lafrance, Marc. 1973. "Coade Stone in Canada," *Bulletin of the Association for Preservation Technology,* Vol. 5, No. 3. Ottawa.

Mack, R. 1983. *The Technology of Historic American Buildings.* The Foundation for Preservation Technology, Washington, DC.

McKee, Harley J. 1977. *Introduction to Early American Masonry: Stone, Brick, Mortar and Plaster.* 2nd printing. National Trust for Historic Preservation, Washington, DC.

Prudon, Theodore H.M. 1976. "Terra Cotta as a Building Material, A Bibliography," *APT Communiqué,* Vol. 5, No. 3. Ottawa.

Ritchie, T. 1970. "Terra-Cotta in Canada," *The Canadian Architect* (August), pp. 56-57.

Ritchie, Thomas. 1967. *Canada Builds 1867-1967.* University of Toronto Press, Toronto.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

6

PERIOD METAL WORK

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICE
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: D. BOUSE /G. SHEMDIN

CONTENTS

1.0 INTRODUCTION

Considered by the Aztecs as more precious than gold, meteoric iron was probably the first iron used. Primitive methods of smelting iron ore were in use by about 2000 B.C. and the classical world made much use of iron largely for weapons and small tools. The industry grew in medieval days, receiving a boost with the "invention" of cannon in the early 15th century and the resulting demand for cast-iron mouldings. In mid-18th century England, smelting with coke in lieu of charcoal was introduced. This produced higher furnace temperatures facilitating the production of steel, previously too expensive for making anything except edge tools. It also produced better and cheaper cast and wrought iron which encouraged their use in bridge and building construction.

The Coalbrooke bridge, erected in 1775 in England, was the first major structure to use cast iron. In buildings, the use of iron began with the replacement of interior wooden structural members – at first in British mills where fire was a constant hazard. One of the earliest major buildings to use cast and wrought iron in England was the Crystal Palace, erected in 1851. The first structure with a complete load-bearing frame was the Eiffel Tower, erected in Paris in 1889.

In the United States iron was used in bridge construction in the 1830s and 1840s and in a limited way for columns supporting the wooden beams in buildings. By mid-century, there was a growing interest in the use of cast-iron ornaments and complete frontages for commercial buildings, designed in most cases to resemble stone. And in 1856 James Bogardus, an iron monger with a foundry in New York, published *Cast Iron Buildings: Their Construction and Advantages* and claimed to have erected the first complete cast-iron buildings in the United States.

Rising land values in their growing cities created a demand for taller buildings, now possible due to the advent of the elevator in 1854. The early "high rises" used cast and wrought iron for the interior framing but retained heavy exterior walls. Even with the transition to steel by William LeBaron Jenny in the building of the Home Insurance Co. building in Chicago, where cast and wrought iron were used for the first six floors and steel for the next three, the exterior walls were made of masonry. The first all-metal high rise was the 12-storey Tacoma Building in Chicago built in 1889, followed by numerous skyscrapers. These eventually abandoned imitating stone exteriors and were designed to best reflect the new framing techniques. In Canada, the first use of steel framing for larger buildings was a seven-storey building erected in Montréal and the 12-storey Union Bank building in Winnipeg erected in 1904.

1.1 HISTORY IN CANADA

The earliest iron works in Canada at *Les Forges du St. Maurice* was established in Trois Rivières in 1733. By the end of the century other Quebec forges were in operation – at Batiscan and Drummondville, among others. In Nova Scotia the Wilmot Iron Works was built in 1790 and in 1800 the Lyndhurst operation began in Upper Canada.

Many forges were established in the 19th century in the Atlantic provinces, Quebec and Ontario – in Quebec alone there were eight set up between 1860 and 1880. Many of these were short-lived. Their failures were due in some instances to lack of experienced metallurgists, inefficient machinery and methodology and in others to a lack or exhaustion of ore or fuel supplies. Others, however, operated for a number of years: St. Maurice until 1883 (at that time claimed to be the oldest active forge in North America); Moose River Ironworks in Annapolis County operated intermittently from 1825 until 1872; the Iron Works at Clementsport, also in Annapolis County, was active from 1831 to 1860; the Normandale Iron Works near Potter's Creek on Lake Erie was productive from 1823 to 1847; and the Acadia Iron Works at Londonderry, Nova Scotia, one of the earliest blast furnace operations, was active from 1850 to 1871.

Fuel used in the early forges was charcoal and the air blast was created by waterwheel-driven bellows. The product was a molten iron suitable for casting which was used for the manufacture of domestic utensils such as pots and kettles, axe heads, artillery parts and stoves. The latter were cast as a series of plates which were bolted together. With a thickness of 50 mm (2 in.), such stoves resisted cracking, unlike thinner imported models not designed to cope with the cold Canadian climate. Later stoves, however, were made of much thinner plate, cast with a variety of surface designs.

In the mid-19th century the production of wrought iron began, but it was not until 1883 in Sydney, Nova Scotia, that the first steel was produced.

During the latter half of the 19th century, there were many improvements in manufacturing methods: the use of coke for fuel and the introduction of blast furnace operations, among others. The product from many of the forges was very good, but

Les Forges du St. Maurice - Chimney Stack

production and transportation costs were high. This resulted in a self-defeating situation in which the demand was low because of the costs and the costs high due to limited demand.

However, by 1900 the smaller charcoal-fueled furnaces had all but disappeared and the industry was firmly established on a larger scale. This was accomplished by using the improved techniques now available and consolidating individual mills to facilitate efficient and economical operation. Also by this time, the acceptance and growing popularity of iron and steel framing was stimulating the demand, especially for rolled steel.

In 1902, the Algoma Steel Company, established in 1898 at Sault Ste. Marie, began producing standard steel rails – the first in Canada; in 1905, Canada's third major steelworks was established at Sydney, Nova Scotia; shortly after, the Hamilton Blast Furnace Co., established in 1895, merged with the Ontario Rolling Mills to form the Hamilton Steel and Iron Company which became the Steel Company of Canada.

In Canada the first use of structural iron, though not Canadian-made, was probably in the Parliament Buildings in 1867. There the architects Fuller and Jones utilized a flooring system patented by Messrs. Fox and Barrett in England in 1844 which involved a system of wrought-iron beams and joists supported by cast-iron columns. Wooden strips spanned the joists resting on the bottom flange of the I-shaped sections and concrete was poured over all. Fuller and Jones also designed an iron framework for the roof of the Parliamentary Library.

2.0 DEFINITIONS, CHARACTERISTICS AND MANUFACTURE

The difference in appearance, strength and workability of cast iron, wrought iron and steel depends basically on the amount of carbon in the iron. This is controlled in the manufacturing process by variations in the levels of heating and cooling and the additives. The production of any one of them requires the iron ore, a heating agent and a cleansing agent.

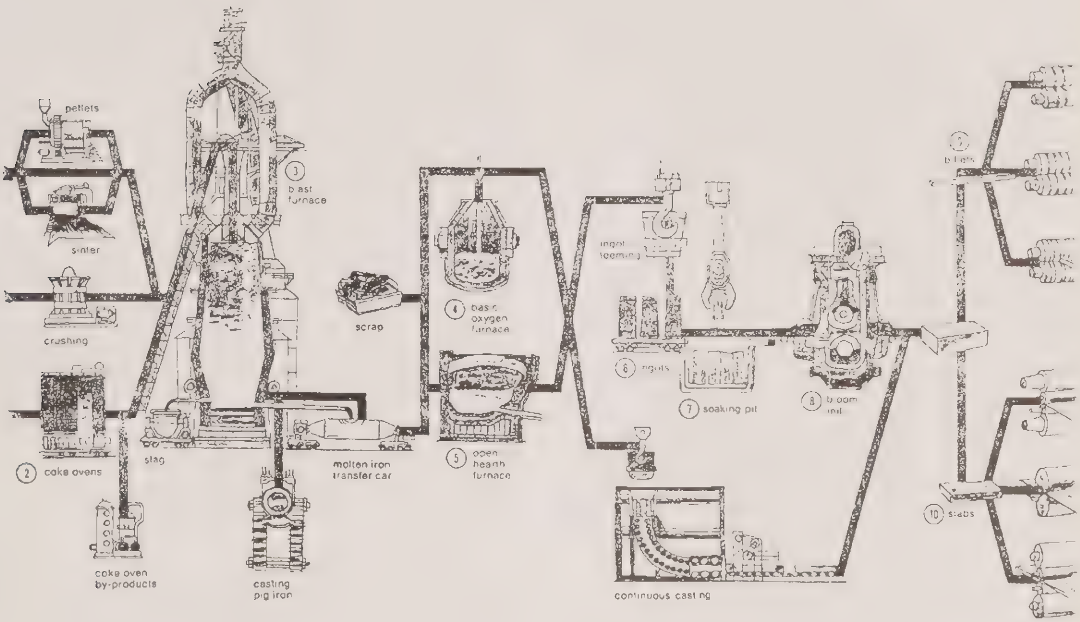
The heating agent was originally charcoal obtained from burning wood. This was gradually replaced by coke produced from coal which became the accepted fuel because it created much higher temperatures than were possible with charcoal. In some modern, small furnaces, electricity now creates the required temperatures.

The cleansing agent or flux is crushed limestone which, in the process of the smelting, combines with impurities in the ore and forms slag.

The manufacturing process and characteristics of pig iron, cast iron, wrought iron and steel are well detailed in several books; the following brief summary is from *Construction Materials and Processes* by Don A. Watson.

Pig Iron: Produced by the combination of iron ore, limestone and coke subjected to high heat. The limestone combines with impurities in the ore and is drawn off as slag; the molten metal flows into sand or metal moulds to form pigs. Pig iron has no structural qualities and must be remelted to eliminate unwanted elements.

Cast Iron: Irons that contain over 1.7 percent carbon and can be poured into moulds; produced by the smelting of a mixture of pig iron and iron or steel scraps. Cast iron is brittle and low in tensile strength; it is high in compressive strength and can be readily moulded.



The Process of Steel Production (Watson)

Wrought Iron: Produced from nearly pure, molten iron combined with molten slag. It contains less than 0.12 percent carbon, is soft and easily worked, and has a fibrous character when broken.

Steel: Produced by the addition of scrap steel, which may consist of several types of alloys, along with pig-iron melt, heated under carefully controlled temperature and time. The product is a malleable alloy of iron and a maximum of two percent carbon; it is fine grained and high in both compressive and tensile strength and consequently has replaced wrought iron for construction purposes (Watson, pp. 103-6).

3.0 ORNAMENTAL METAL

3.1 CAST-IRON FAÇADES

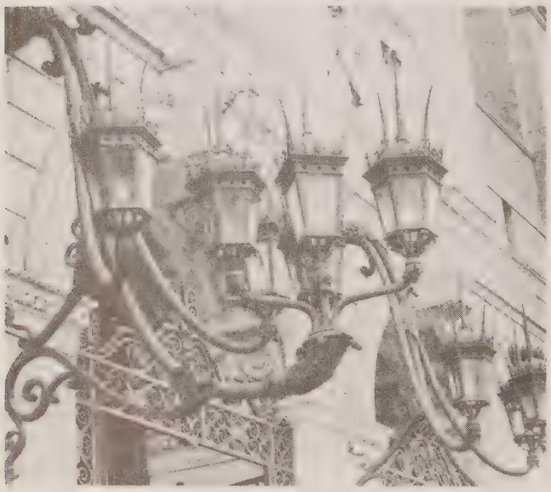
Early cast-iron façades, which had become popular in America by mid-19th century, were initially designed to resemble stone. Elements of the design, such as columns and pilasters, retained the proportions of their stone counterparts. However, the scale and style of the lavish decorative details made possible by casting rather than carving was exploited in meeting the current demand for more decorative buildings, in contrast to the austere formality of the preceding Neoclassic era. However enthusiastically this new style was promoted, it was not universally accepted. Claims or expectations that cast-iron façades were a form of fireproofing were dispelled when it was realized that not only did the metal melt, but iron façades had been known to collapse in major fires and their high temperature set fire to areas otherwise untouched. However, it also became evident that if allowed to stand on its own merit, iron could be used to eliminate the bulk of other building materials. Slimmer columns and spandrels, allowing more glass area, were welcomed by the growing retail industry which wished to maximize display area on the front of their buildings as well as maximize interior floor space by using iron columns. Traditional styles still were copied, but were restrained in the use of attached ornament.

Before James Bogardus promoted the all-iron structure, metal façades were simply applied to wooden or metal framed buildings or replaced the façades of older structures.

Canada acquired cast-iron façades in the mid- and late 19th century from Britain and from America. The Architectural Iron Works of New York supplied façades for buildings in Brant, Peterborough and Halifax. Prefabricated buildings were sent from England to Victoria. Canadian foundries, however, by the 1870s were producing architectural details for façades, and locally produced elements adorned many turn-of-the-century buildings in Victoria, Toronto, Montréal and Halifax. Many of these buildings survive but have not as yet been completely inventoried or documented. The most detailed inventory currently available appears to be a section of Montréal in *Montreal – Cast Iron Architecture* by J. Bélisle, et al., listing some 150 buildings having cast-iron elements on the façades.

Early iron workers faced many problems in making smooth surfaced castings with a consistent texture. Obtaining a good, fine grained sand to either form or line the mould, allowing for shrinkage of the casting, provision of vents for escape of air and gases during the filling process and the provision of cores, if required, were all necessary for a fine product. The skill of some craftsmen was such that the cast-iron work cannot be distinguished from wrought iron.

The art of iron casting is also evident in the numerous styles of cast-iron stoves that have been the specialty of several foundries from the days of Canada's first foundry at St. Maurice. While one may marvel at, rather than admire,



A Combination of Cast and Wrought-Iron Work

the designs of some of these stoves, certainly the skill in production is something to note. Simpler ornamental casting was found on firebacks which provided a decorative fireproof covering for the brick or stone lining of a fireplace and was popular in 19th century fireplaces. Street furniture such as railings, streetlamp bases, fountains, benches, water troughs, steps and stairways were among the usual cast-iron products. These were treated in the foundry to prevent rust and were very often painted on-site.

Devotees of wrought-iron work praise the individuality of the craftsmen working in this media. Unlike casting, each piece is individual and has a resultant liveliness. Decorative wrought-iron architectural detail is usually finer in scale than that of cast-iron and displays a crispness that is almost impossible to achieve in casting. Outstanding among the many items produced in wrought iron are the highly individual crosses produced in early Quebec to mark wayside shrines. Grilles, gates, railings, hardware and a host of other objects bear witness to the skillful craftsmanship of the ironmaster.

Finally, any discussion of wrought-iron work in early Canada must pay tribute to those essential members of the early communities – the local blacksmiths. With the primary responsibilities of shoeing horses and making nails, hinges, hardware and tools of all kinds, many displayed an innate sense of good design in making even the most utilitarian of tools or domestic utensils. Subject of many songs and stories, the early "village smithys" well deserved this reputation for fine craftsmanship.

4.0 SHEET METAL

The use of sheet metal for ceilings, roof coverings and cornices reached a peak of popularity in the late 19th century.

The forming of sheet metal by rolling was developed in Britain in 1825 and a few years later a method of galvanizing the sheeting by dipping it in molten zinc to prevent rusting was invented. Corrugation was added to provide stiffness and the resulting corrugated galvanized iron roofing became immensely popular both in England and North America. It has been widely used in Canada as a roofing material, particularly for shed and warehouse structures.

Plain galvanized iron was used for ceilings, initially in institutional buildings. Corrugated sheets were seen too, but the introduction of sheet metal ceilings stamped in decorative designs soon took over and reached a peak of popularity in

Canada in the early 20th century. They came in foot square tiles or in sheets 600 mm (2 feet) wide and up to 2.5 metres (8 feet) long. The tiles or sheets were interlocked and nailed to wood furring strips. They were stamped in a series of repetitive patterns or arranged on the ceiling to form a simple design. Advertised as durable, fireproof and inexpensive, they lived up to these claims and were widely used in public buildings and houses of modest style.

Metal sidewalls were also advertised for interior use, but much more extensive was the use of stamped metal for covering the exterior of buildings. The metal could be stamped in a design and the surface made to resemble stone or brick; trim and cornices duplicated classical mouldings and when in place and painted often took a discerning eye to recognize the duplication. Very ornate designs for door and window trim and for cornices were stamped onto iron or copper sheeting and given a coat of paint before leaving the factory. Walls were generally painted grey to resemble stone (if stamped in that pattern) – when well done the deception could be most successful.

5.0 BIBLIOGRAPHY

Arthur, Eric, and Thomas Ritchie. 1982. *Iron.* University of Toronto Press, Toronto.
A detailed account of Canada's early iron and steel works, illustrated.

Bélisle, J., N. Volesky, et al. 1976. *Montreal Cast Iron.* Catalogue for an exhibition in Montreal.
This also lists foundries from John Lovell's *Montreal Directory* from 1842-1920.

Gillespie, A. 1983. "Ceilings of Metal," *Canadian Heritage,* No. 40 (May-June), p. 9.

Mesker, Geo. L. 1905. "Catalogue of Store Fronts," *Bulletin of the Association for Preservation Technology,* Vol. 9, No. 4, 1977, pp. 3-40. Ottawa.

Watson, Don A. 1986. *Construction Materials and Processes.* 2nd edition. McGraw-Hill Inc., New York.
Quoted material and illustrations are reprinted by permission: ©1986 Glencoe Division of the Macmillan/McGraw-Hill School Publishing Company.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

7.1

PERIOD CARPENTRY: LOG CONSTRUCTION

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: KEN ELDER

CONTENTS

1.0 INTRODUCTION

There is a scarcity of good historic documentation on log construction. This gap may be a result of the general lack of formal education among master carpenters who developed their skills through apprenticeship and on-the-job training involving little, if any, printed instruction. The topic was all but ignored by the European authors who produced many 18th- and 19th-century technical books.

Where historic documentation does exist, problems of typology (language) make interpretation difficult. Illiteracy, careless usage, use of local terms and spelling and pronunciation variations all contribute to the confusion.

The scarcity of available documentation and research weighed against the huge scope of this subject. It was impossible to draw firm conclusions on the relative merits of the various construction materials and methods or on the degree to which they were used.

The aim of this article, therefore, is to present a sampling of available information. The selection of quotations from authors with divergent backgrounds and philosophies is intended to present as broad a view as possible of the preserved traditions and rediscovered building methods.

Readers are left to judge the accuracy of the sources quoted and to use each excerpt according to their own requirements. This article may also assist the architect, engineer or technologist to select source material for further study.

Log and Stone Construction (Wigginton, p. 56)

2.0 PERIOD FIELD PRACTICE

2.1 JOB PLANNING

A master or boss carpenter in full control of a building operation was frequently called upon to predict with some accuracy the cost, in time and money, of doing the work. A trip to the site to assess field conditions and scope of work was made. A bill of quantities (materials) and a cost estimate were usually, but not always, prepared.

2.1.1 Assessment of Field Conditions and Scope of Work

The tradesman inspected the site to provide detailed information on:

a. general layout, e.g. lay of the land, kind of water, distance from shipping point of materials and supplies, character of the country, etc.;
b. character and availability of labour; and
c. rate of wages.

Consultation with the owner and examination of the design provided information on:

a. the amount of work translated by the tradesman to cubic measure, superficial (square) measure or lineal (running or run) measure;
b. the time of year work would be done and effect of anticipated weather, i.e. number of rainy days or days of excessive frost;
c. kinds of material to be handled and its quality;
d. kinds of tools required; and
e. time for completion.

A more complete description of the factors considered under field conditions can be found in *Radford's Cyclopedia of Construction, Carpentry, Building and Architecture.*

2.1.2 Bill of Quantities

On the basis of verbal instruction or drawings provided by the owner, the workers drew up a list of the major (and in some cases the minor) building components. Preceding each component (properly named and described) on the list was an estimate of the quantity required. A cost for individual components was often added. This was expressed in various ways: cost per unit of length or multiples of length, such as hundreds or thousands; of volume (commonly expressed in "board feet" or "board measure," containing or derived from approximately 2000 cm^2 of rough, green lumber); or per piece (or lots of 100 or 1000). Occasionally other units, such as a "cord" (volume of logs roughly 1.2 x 1.2 x 2.4 m or 3.5 m^2) might be used. The following bill of quantities, prepared ca. 1857 for a group of *colombage pierroté* and horizontal log buildings, is more or less typical of the format:

Statement of Oak timber required for building Stables, Sheds, etc. at Lower Fort Garry…

30	pc's	Oak	22	feet	long	10x10	ins.	3/.
12	–	–	22	–	–	9x9	ins.	2/6
12	–	–	22	–	–	8x7	ins.	2/6
4	–	–	30	–	–	10x10	ins.	4/.
3	–	–	24	–	–	9x9	ins.	3/6
48	–	–	30	–	–	8x7	ins.	3/6
4	–	–	30	–	–	8x7	ins.	3/.
200	–	–	20	–	–	building logs squr'd on 2 sides		1/6
280	–	–	15	–	–	building logs squr'd on 2 sides		1/2
9	–	–	16	–	–	building logs squr'd on 2 sides		1/3
9	–	–	28	–	–	building logs squr'd on 2 sides		2/.
10	–	–	17	–	–	building logs squr'd on 2 sides		1/3

(NA., *Lane Papers*)

pc's = pieces
ins. = inches (25.4 mm)
3/6 = 3 pounds sterling/6 shillings
squr'd = squared

2.1.3 Estimate of Cost

The estimate of cost for a log building or work took many forms depending on the knowledge, training or preference of the writer, but some content similarities were found. Most contain a bill of materials, a breakdown of the carpenter's work and entries for the work of other trades, all properly costed and totaled.

For an example, typical of those covering palisading and stockade work, the reader is referred to an estimate for picketing preparing by Royal Engineers in 1799 for Fort George (Desloges, pp. 142-43).

For examples relating to residential horizontal log construction, the reader is referred to an estimate prepared by a civil carpenter in 1785 for two round log houses and another in 1794 for a squared log building, both reproduced in *Building with Wood* (Rempel, pp. 69-70, 72-74).

2.2 LOCATING MATERIALS

Much of the material used in building a log structure was obtained when the site was cleared. In many instances, clearing was a necessary requirement for getting legal title to a parcel of land (Rempel, p. 32).

William S. Wicks, writing in 1928, saw the local supply of straight timber for building logs as essential in choosing the building site. One advantage of a waterfront site was that logs could be floated in from a distance.

B. Allan Mackie, writing in 1971, suggested obtaining lumber from Crown land, a commercial log producer or the site itself. He warned, however, against depleting "the woods surrounding your new home" (Mackie, p. 22).

A description of clearing is provided by Gilles LaFrance:

> The felling axe, well sharpened, was carried to a soft wood thicket and swung mightily from dawn till dusk. Trees grew so tightly together that three of them had be to cut down before any timber reached the ground. The same axe was used to branch and bark the trunks. Branches served to make a temporary shelter and the trunks were hauled to a spot on a knoll where the new cabin would be erected (LaFrance, p. 1).

In many cases, a search further afield for building materials was necessary. In erecting the Commanding Officer's residence at Battleford in 1876, the foreman in charge undertook such a search:

> His quest for large timber took him far afield, riding horseback, crossing lakes in a canoe and tramping through wooded areas. Some of his logs were cut 60 miles beyond Edmonton and rafted down the Saskatchewan. They were then hauled to the site of his work where he had set up his portable sawmill. Smaller timber was obtained from the neighbouring Eagle Hills (Desloges, pp. 142-43).

In the logging industry, where cutting was organized on a much larger scale, the lumbermen were preceded by a timber cruiser who travelled by canoe and on foot in search of groves of marketable timber (Hughson and Bond, p. 79).

2.3 SELECTING MATERIALS

2.3.1 Species

A great variety of tree species were used in palisade and horizontal log construction. The Reverend William Wilson in 1866 describes a Newfoundland tilt made of "rough spruce sticks about 6 inches diameter…." (Tibbetts, p. 4). A report and estimate for enclosing with a "Defensible Picket Fence" at Butler's Barracks, Niagara, 1839, specifies pine pickets 11 feet long (McConnell, p. 120). Archaeologists, who in 1965 excavated a prison palisade built after June 1870, in Lower Fort Garry, identified it as white oak. A search of historic documents would show a similarly broad range of species for horizontal log structures.

Clearly, the closest tree species which had suitable dimensions was most often chosen. One suspects the builder was seldom allowed the luxury of debating the merits of various species according to the selection criteria recorded by John I. Rempel:

> Larch was frequently used in the United States for foundation logs since its wood was supposed not to be as much affected by moisture as were other woods. Cedar and then hemlock were considered by the settlers to be the most durable woods in normal situations. Hemlock was also supposed to process the peculiar property of preserving iron driven into it from rusting, either in the air or under water. Many settlers were quite convinced of the superiority of American timber over European, although it was conceded that the American yellow pine was not as durable as the Norwegian red pine, but was better adapted, all the same, for certain (unstated) purposes. Pitch pine, red pine and larch were agreed to last as long as any similar European lumber (Rempel, p. 32).

Twentieth-century writers differ considerably when recommending the selection of timber for a horizontal log structure. Wicks recommended spruce, pine, hemlock, tamarack and balsam (Wicks, p. 12). Fickes and Groben recommended cedar, pine, fir and larch, in that order (Fickes and Groben, p. 2). Mackie

listed (in order of preference) cedar, Douglas-fir, pine, spruce, hemlock and balsam and commented on the characteristics of each for building use (Mackie, p. 23).

Enormous Size of West Coast Redwood

The question of log selection was discussed by the Forest Products Laboratory, Forest Service, U.S. Department of Agriculture in 1960. Its comments on natural decay resistance explain to some degree the successes and failures experienced by log builders in the past. It pointed out that variations in natural decay resistance occurs in heartwood. The heartwood of cedar, redwood and bald cypress are particularly resistant, but that of species such as aspen are poor. With all species, decay occurs less in cold or dry climates than in warm and moist ones.

2.3.2 Quality

Selecting logs for a project meant not only settling on a particular species, but choosing individual trees in a state of growth or bucked logs on the basis of some quality measurement. Historical references to this aspect of selection are few. Joseph Gwilt in *An Encyclopedia of Architecture, Historical, Theoretical and Practical* offered:

> If the architect has the opportunity of selecting timber whilst in a state of growth, he will, of course, have chosen healthy, vigorous and flourishing trees. Those in which the trunks are most even are to be preferred. A mark of decay is detected in any swelling above the general surface of the wood. Dead branches, especially at the top of the tree, render it suspicious, though the root is the best index to its soundness. The notion of Alberti (*De Re Aedificatoria*), of using all the timber in the same building from the same forest, is a little too fanciful for these days.... (Gwilt, pp. 494-95).

This reference referred mainly to the selection of trees primarily for conversion to half timber or scantling.

It is unlikely that a full account of how building logs were selected in the past will ever be located. One can only speculate on which criteria routinely employed today were considered important historically.

When selecting trees specifically for building, the logs' straightness and uniform size are important considerations:

> To judge if a tree is straight, first look at it from a distance of about 100 feet and from two sides, at right angles to each other. If no sweep or crook can be seen in the required length, move in close and sight up the tree. It must be very straight to appear so from this angle (Mackie, p. 22).

Assessing the quality of standing trees and bucked logs is nowhere as developed as it is in the timber industry. There, the concern has always been to predict, as accurately as possible, the lumber recovery from particular trees or logs. The most significant factors in estimating lumber recovery of a standing tree are such things as:

- species
- dimensions, diameter, breast height, tree height
- position of limbs, height of first dead limb, height to first live limb, very low branches
- size of branches, very large branches (over 3.0 in. dia. or over 75 mm in dia.)
- bark thickness
- stump height

- crown length, density, width
- age
- lean, amount
- clear bole (trunk), height
- decay indications
- sweep or crook
- fire scar

(Csizmazia, McIntosh, McBride, Gunn, pp. 15, 22, 24, 26, 27).

On bucked logs, consideration is given to such things as:

- species
- dimensions, top diameter max. butt diameter length
- knots, number of clear sides, number of large knots, number of total knots
- defects, four categories
- bark thickness.

A handbook provided to the "log scaler" and "timber cruiser," the individual responsible for gathering such data, divided defects into the following categories:

- interior defects, which cause waste in the interior of the log
- side defects, which cause waste on the outside of the log
- defects from curve or sweep
- defects from crotches
- defects from an excessive number of knots (Dilworth, p. 34).

A list of specific defects which might be encountered, noted in the same handbook, is extensive – centre or circular rot, butt rot, sap rot, conk rot, cat face or fire scar, roughness, knot clusters and burls, snake and pitch ring, heart check, pitch seam or split, lightning defect, crook or sweep, wind or sun checks, stains, crotch, worm holes and break.

2.3.3 Sizes

Few surveys of horizontal log structures have been conducted for the purpose of gathering information on log size. John Rempel, one of the few individuals to gather data in this area, reported diameters ranging from eight to eleven inches (Rempel, p. 39).

Statements on log size are made by a number of writers. William S. Wicks suggested that the strongest, largest and best shaped be used for the sills or first tier of logs (Wicks, p. 13). Fickes and Groben, while agreeing that the larger logs should be reserved for the bottom of the walls, added:

> The selection of straight, smooth, even-sized logs is the prime consideration.... Top diameters should be as uniform as possible. For logs longer than 40 feet, the top diameter may be less in order to avoid an excessive diameter at the large or butt end (Fickes and Groben, pp. 1-2).

When choosing logs appropriate for a particular size of building, Mackie recommended larger logs for larger buildings, suggesting logs 355 to 400 mm at the butt for a building 9150 mm square. He also stated:

> If in doubt, always err on the side of bigness for not only do the logs shrink but the added size is helpful in several ways – thicker and therefore better insulated walls, fewer notches to cut, a more solid appearance and, of course, superior strength (Mackie, p. 22).

For the size of stockade and palisade members, one suspects reference was made to such military manuals as *A Treatise Containing the Elementary Part of Fortification, Regular and Irregular* by John Muller, 1756 or the *Aide-mémoire to the Military Sciences*, 1852. The latter, under the head PALISADES, stated that: The palisading should not be of less dimensions than 6 inches in diameter and from 10 to 12 feet long, of which 4 should be fixed firmly in the ground (*Aide-mémoire, Vol. III*, p. 40).

2.4 FELLING, TRIMMING AND BUCKING

2.4.1 Cutting Time

Several 20th-century writers discussed the best time of year for cutting building logs:

> The bark will peel from the trees in the Adirondacks from the first of May until the last of July or even later if the season is damp, but comes off most readily in the month of June. If you want the bark left on the logs, the late fall or winter months should be selected for cutting time. (Wicks, p. 12).
>
> ....
>
> It is best to cut the logs in the late fall or winter for two important reasons: 1. Logs cut in spring or summer peel easier, but crack or check to an undesirable degree while seasoning. 2. Insect activity is dormant during the winter months; hence, if the logs are cut and seasoned then, they are less liable to damage by insects or rot-producing fungi (Fickes and Groben, p. 2).
>
> ....

> Logs are best cut in winter when the sap is down in the tree. Logs may be skidded readily and cleanly on the snow, with much less danger of mechanical damage. If winter cutting is impossible, the next best times are late fall and, after that, summer. But spring cutting is the least preferable…even though spring-cut logs do peel much more readily. The disadvantage is that they are so heavy with sugary sap in this season, they are very susceptible to mildew and staining. Being swollen, they seem more susceptible to subsequent checking too (Mackie, p. 24).

The historical references to cutting time dealt specifically with trees destined for conversion to half-timber scantling, quartering, etc., and have therefore not been reproduced here.

2.4.2 Felling

Both axes and saws were employed in the past to fell trees. The authors of *Hurling Down the Pine*, a history of timber and lumber manufacturers in the Hull and Ottawa region, contended that the crosscut saw "generally supplanted the other" in the last quarter of the 19th century:

> Before the introduction of the cross-cut saw for felling, the men of the shanty were divided into teams of three axemen each, each three with a teamster and a pair of horses. After the use of the cross-cut saw became common in felling about 1870 (it had been used much earlier in cutting up logs), a felling team would consist of two men only, the "feller" and his assistant (Hughson and Bond, p. 85).

Determining the direction of fall for a chosen tree was one of the first tasks for the axe-man or sawyer, governed by the following factors:

> 1. The lean of the tree. By the use of wedges a straight tree may be sawed to fall in any direction. Heavily leaning trees can be thrown by the same means in any one of three directions, namely, as it leans or to either side. Where a tree leans only slightly and its inclination cannot be determined readily by the eye, an ax handle held suspended like a plumb line between the line of sight and the tree will serve as an indicator.
>
> In determining the direction of fall the choice is influenced by the shape of the crown. Very few crowns are symmetrical, one side often being heavier than the other, because of better light conditions. This preponderance of weight on one side acts as a powerful lever and, therefore, must be considered by the faller.
>
> 2. The avoidance of lodging one tree in another.
>
> 3. The selection of a spot where the bole will not be broken on stumps, rocks or other objects. This requires special attention in handling large or brittle timber….
>
> 4. The simplification of skidding work. In brushy regions it is desirable to fell trees parallel to the skidding trail, since this aids the teamster in getting out the logs. …Timber on slopes should be felled either up or down according to the location of the nearest accessible skidding trail. Trees felled up steep slopes are less subject to breakage because the distance of fall is less. It is, however, a more dangerous method because the trees may shoot down the slope (Bryant, pp. 89-90).

A cautionary note regarding "great branches" was provided by Joseph Gwilt in his book *An Encyclopaedia of Architecture Historical, Theoretical and Practical*:

> In felling not only the oak, but all other large trees, the great branches should be first cut off, so that the tree may not be injured or stained in its fall and the trunk, moreover, must be sawed as close to the ground as possible (Gwilt, p. 495).

R.C. Bryant described felling with a saw and with an axe:

> The saw-cut is started on a level with or slightly above and opposite the undercut. When the saw has buried itself, wooden or iron wedges are driven in behind it to prevent binding. As sawing proceeds the wedge point is made to follow the back of the saw by occasional blows. Sawing in a direction parallel with the undercut progresses until the tree begins to fall, whereupon one sawyer withdraws the saw and both seek a place of safety (Bryant, pp. 93-94).
>
> • • • •

> A wedge-shaped notch or undercut is made on the trunk in the direction of fall, to guide the tree and to prevent the bole from splitting before it is completely severed from the stump. It has a horizontal base extending slightly past the centre of the tree if felling is done with the ax, and from one-fifth to one-fourth of the diameter when felling is done with the saw. The undercut on trees that lean heavily in the felling direction is made deeper than usual in order to insure a clean break. On those that lean away from the felling direction a small notch is cut because it gives the wedges greater power....
>
> The notch should be placed about 4 inches below the point at which the felling cut is started on the opposite side. Its height above ground is determined entirely by the policy of the logger regarding stump heights. Notches are generally cut with the ax, but the horizontal cut may be made by a saw and the notch completed with an ax.
>
> ....
>
> In felling with an ax, the operation begins by cutting a wedge-shaped notch opposite and slightly higher than the undercut. This cut is continued towards the center of the bole until the tree falls. Wedges cannot be used in felling with the ax, therefore, it is more difficult to throw a tree in any direction except that in which it leans. It is estimated that from 10 to 20 board feet per tree of spruce is lost when the ax is used exclusively for felling and log-making (Bryant, pp. 92-93).

Felling techniques are also discussed in two more recent publications, *Hurling Down the Pine* and *Building With Logs*.

2.4.3 Trimming off the Branches

Two rather brief references on the subject of trimming have been located:

> When felled, but not before, if the trunk is to be barked, trimmed of its branches and left to season (Gwilt, p. 495).
>
> ....
>
> ...The first step in log-making is to cut the limbs from that portion of the bole which is to be utilized. This is done with an ax by a member of the saw crew or by a special man called a swamper, knotter or limber (Bryant, p. 98).

2.4.4 Bucking (cutting to proper lengths)

The bucking of trees for suitable building logs was passed over in the available historical accounts of log building. A description of bucking with an axe in commercial logging, presumably related by one familiar with the operator, was recorded in 1918. Although the described procedure was intended to produce "saw logs" for a water mill carriage, it was undoubtedly similar to the bucking of trunks into building logs.

> It was not unusual within the memory of men still living, for trees to be converted into saw logs with axes, the chopper squaring both ends of the log and in the process wasting about a foot of each log's length. The axman stood on the log and chopped the trunk off. He made both sides of the notch square as he proceeded, thus really cutting the trunk off twice for each log, which was not only a waste of time but a waste of wood... The employment, of a saw in cross-cutting was the first important conservation step in logging... (Dixon, p. 22).

A description of bucking-up with a two-man, cross-cut saw, felling axe and wedges during logging was provided by R.C. Bryant.

A decision on log lengths was clearly related to building dimensions. One author suggested cutting logs at least 610 mm longer than the finished dimensions (Wicks, p. 13); another recommended an extra 1500 or 1800 mm:

> ...to provide ample material for finishing of the log ends and also to overcome the danger of a too-short log coming off the walls when it is being rolled across the building and one end of it falling into the interior... (Mackie, p. 22).

2.5 TRANSPORTATION

2.5.1 Land

Historically, logs were moved on land by both hand and animal draft power methods:

> Saturday, 9 June 1753 The Settler's carried up on ye shoulders the timbers of one blockhouse, (The distance being near half a mile (Young, p. 213).
>
> ....

In surveying parties 14 men with a pair of Oxen would frequently put up a Log house in a day (White, p. 289).

• • • •

Gramp's method of logging was the same one they have come back to now. They used tractors and he used oxen, but that's about the only difference. He would cut a tree down, limb it off and bob the whole tree – draw it out without cutting it up. He would cut it up into lengths as he wanted it afterward. It was only when they began using horses that they would cut the tree up into twelve-foot lengths on the spot and use a scow or a scoot. Gramp and his oxen would just drag the logs on the ground (Needham and Mussey, p. 88).

• • • •

The prisoner's for the next week will be kept cutting timbers for the stockage. The timber will be got along the Saskatchewan on the flats below the Barracks. S.C. Shaw will draw this timber to the barracks with a team of horses and will be assisted in loading by prisoner or Quinn (Hildebrandt, p. 100).

A variety of hauling techniques using animal draft power were employed; snaking for short distances, sled and wheeled vehicle hauling for longer distances. A description of the equipment used in hauling includes:

- equipment used in snaking logs; i.e. horse harness, yokes, chokers, tongs, drag shackle (skidding grad), etc.
- sleds used in transporting logs; i.e. do-devil (travois or crotch); yarding sled (drag), bob, two-sled (twin sled or wagon sled)
- wheeled vehicles used in transporting logs, i.e. bummers, log carts and wagons

Deciding what hauling technique to use was made after considering such factors as the availability of a particular piece of equipment, the weight of the timber to be handled, the character of bottom, the grade of the trail or road and the distance of the haul.

Transporting Large Timbers

2.5.2 Water

Large streams were frequently employed for the water transport of logs. Small lots, such as those needed for a single building, were floated single or lashed (or dogged) together in a small raft (Hildebrandt, p. 101).

Some of the equipment which might have been used in floating and rafting included hook, jam pike, peavy, ring dog, log tons, pickaroon, raft dog and raft shackles.

2.6 STORAGE AND SEASONING

2.6.1 Storage

No early references dealing specifically with the storage of building logs have been found. Some very general comments on the storage of timber were, however, provided by John Evelyn in 1664 and Joseph Gwilt in 1891:

> Lay up your timber very dry, in an airy place, yet out of the wind or sun and not standing very upright, but lying along, one piece upon another, interposing some short blocks between them to preserve them from a certain mouldiness which they usually contract while they sweat and which frequently produces a kind of fungus, especially if there be any sappy parts remaining (Gwilt, p. 503).
>
> ....
>
> After timber is felled, the best method of preventing decay is the immediate removal of it to a dry situation, where it should be stacked in such a manner as to secure a free circulation of air round it, but without exposure to the sun and wind and it should be rough squared as soon as possible.... The ground about its place of deposit should be dry and perfectly drained, so that no vegetation may raise on it (Gwilt, p. 506).

Wicks, Fickes and Mackie all suggested storing in single or multiple decks on short logs or skids to permit air circulation. Fickes suggested piling curved logs with the curve uppermost so that the weight of the logs will tend to straighten them (Wicks, p. 13).

There is disagreement on peeling. Fickes suggested cutting and peeling before stacking (Fickes and Groben, p. 2). Mackie urged against peeling until the logs are ready to be used because the bark protects against mildew, checking, weathering and mechanical damage (Mackie, p. 24).

2.6.2 Seasoning

Most writing in the past was focused on seasoning for improving the quality of scantling, plank, etc. Advice on seasoning building logs was offered by Mackie:

> The Scandinavian log builders of old had many techniques for seasoning logs without checking. The most amazing I have read about was their method of topping the standing trees, leaving two limbs, then peeling two strips of bark down the sides as the workman returned to the ground; the tree was felled after it stood, like this, for about two years. Such precaution accounts for the beautiful condition of some of their buildings dating from the 1300s. In my own woods experience, I have noted that a tree which might have been bulldozed off a new road, for example and has been down for a year but with its roots and limbs still intact, does appear to have seasoned much better than a tree cut and limbed and stored for a year.... But if you are interested in optimum seasoning of logs, it would appear to occur in much the same manner as a tree's natural death would occur and must, therefore, take at least two years (Mackie, p. 24).

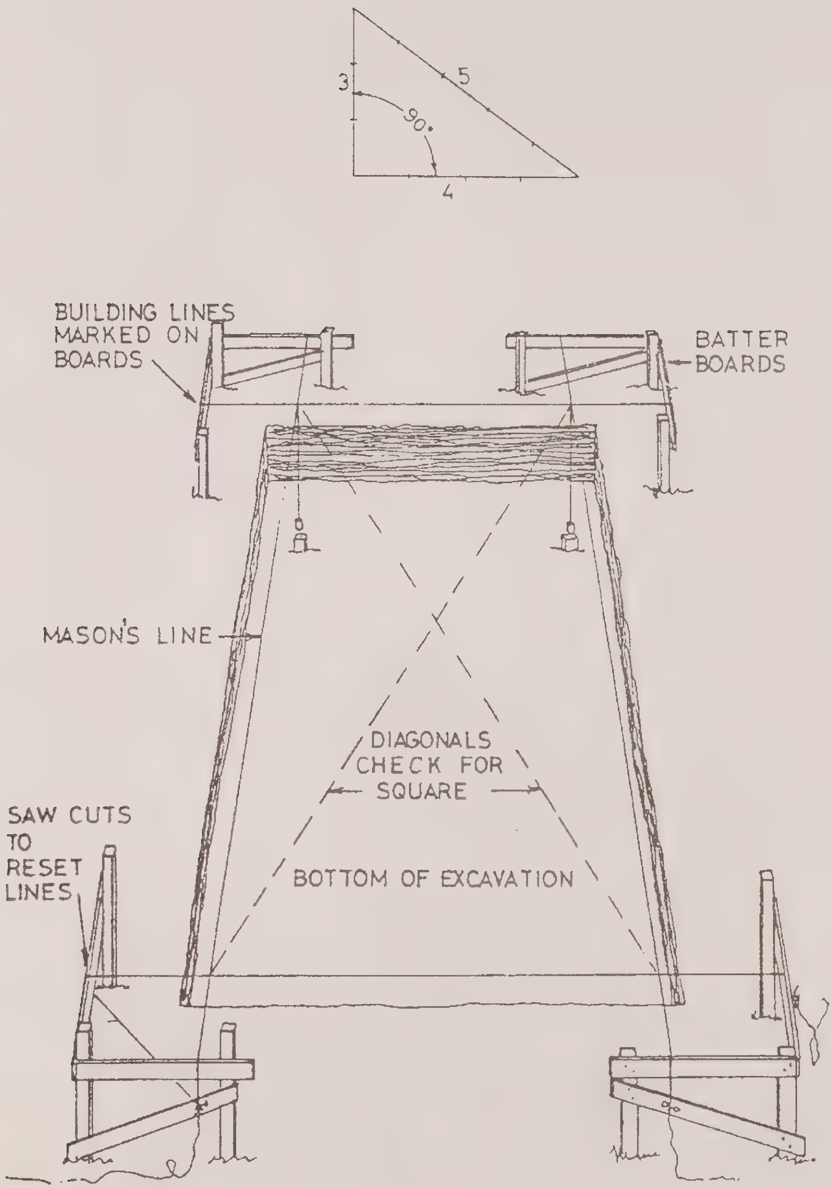
The comment that a tree's natural death took at least two years is an interesting one. The *New Guide to Carpentry, General Framing and Joinery: Theoretical and Practical*, ca. 1867, recommended the same period for seasoning softwoods and three years for seasoning hardwoods.

One wonders if there is some relationship here between natural death and optimum natural seasoning time. Joseph Gwilt referred to the same two-year seasoning period:

> It is thought that the more gradually timber is seasoned the greater its durability; and as a general rule, it may be stated, that it should not be used till a period of at least two years from its being felled and for joiners' work at least four years (Gwilt, p. 506).

Joseph Gwilt also provided information on "seasonings of the fire" which he recommended for posts and piles. He cited John Evelyn who wrote in 1664:

> ...there be seasonings of the fire, as for the scorching and hardening of piles, which are to stand either in the water or in the earth.



"Locating Building Lines" from B. Allan Mackie

> When wood is charred it becomes incorruptible; for which reason, when we wish to preserve piles from decay, they should be charred on the outside. Oak posts used in enclosures always decay about two inches above and below the surface. Charring that part would probably add several years to the duration of the wood, for that to most timber it contributes its duration (Gwilt, p. 503).

2.7 JOB LAYOUT

What little has been written on the subject of job layout, is brief and of recent origin:

> **Staking out and preparing for work**
>
> Having your plans, now stake out the size of your buildings, so that you may know the distance to clear off the ground round about (Wicks, p. 10).
>
> ....
>
> Generally, one corner or one wall is chosen as a starting point for the building's position. Erect batter boards around three corners and at least 4 feet beyond the outside of the foundation line. The corner can be squared by using a triangle measuring in the proportion of 3 and 4 on the sides and 5 on the hypotenuse....
>
> The fourth batter boards may now be located by measurement and the squareness of the building checked by confirming that the diagonal measurements are within 1/4" of being equal. Other foundation lines may now be located easily by measurement (Mackie, p. 26).

Mackie also provided a line drawing titled "Locating Building Lines" illustrated above.

Until a detailed contemporary description of job layout is located, one can only speculate on which techniques were actually used.

2.8 PREPARATION

2.8.1 Building Site

One of the builder's first tasks was land clearing. Historical references to this operation give few descriptive details:

> ...they are squaring some excellent Timber for the Blockhouse (Yamaska Blockhouse (Upper) 1781 and will continue to do so and to clear the Wood for the distance of 250 yards from the Post... (Young, p. 276).
>
> ...I would therefore humbly propose that as much Timber as possible be felled round the Block House Fort Saint John, 1778 to the distance at least of five hundred Yards... (Young, p. 174).

The clearing in these instances was done primarily for military reasons; i.e. exposing an attacker and improving the field of fire.

Localized clearing involved removing roots and rocks and leveling the ground (LaFrance, p. 1). Twentieth-century writers offer the following suggestions for clearing:

> Cut down such trees as may be in the way of the structure and no more, unless there are rotten and unsound trees standing near. These fell at once or a wind-storm may throw one or more across your building (Wicks, p. 10).

2.8.2 Log Members

No special preparation of logs, selected for round log building or work, was required. The usual trimming, cutting to length and peeling operations were completed in the woods.

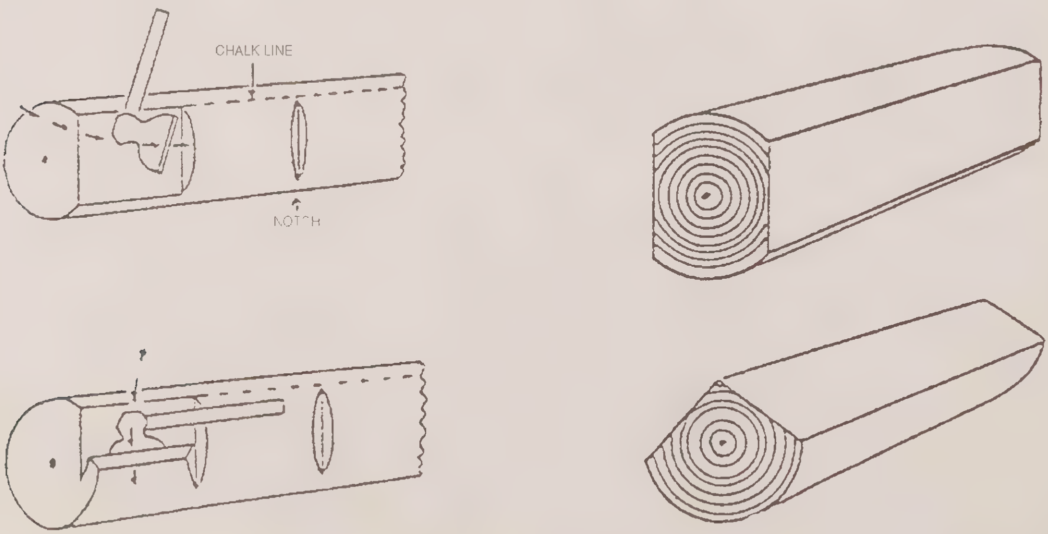
Logs selected for a squared log building or work, on the other hand, have to be hewed into shape. In some instances, this work was carried out where the tree was felled. If the stand of timber was near at hand, the building logs, significantly lightened by the process of squaring, could be safely and easily transported to the site either using log rollers or mere human effort. More commonly, the unpeeled, bucked logs were transported to the site for squaring. The timber stand was frequently at some distance from the site and rafting, hauling or both (using a team of horses or yoke of oxen) was required. The layer of bark protected the inner wood.

From the point of view of those responsible for the hewing, it was important that work was begun while the timber was green. Additional time was sometimes gained by leaving the logs immersed in water.

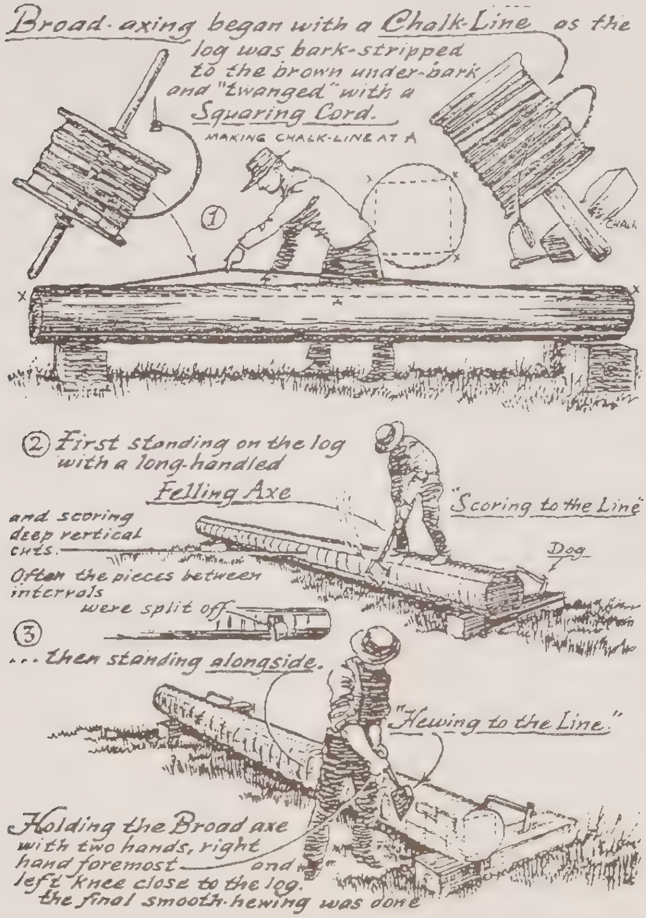
A description of hewing in the bush using the limbs to support the trunk temporarily is provided by *Grandfather's Book of Country Things*, an account of the pioneering experiences of Leroy L. Bond (1833-71) in Vermont:

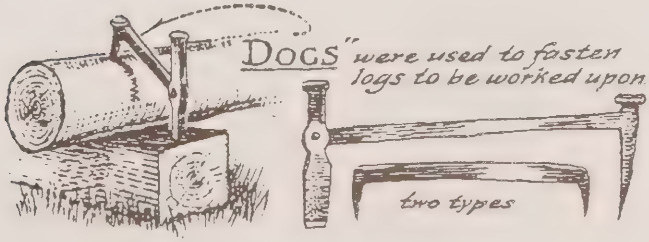
> Once Gramp had found a tree to suit him, he would take the first axe from me, and chop it down. Next he would take a chalkline, a hard string rubbed with chalk. It used to be my job to hold it down at one end. He would hold it tight, and then snap it; generally it would snap out of my fingers the first two or three times because he pulled so tight. Snapping the line would make a long, straight mark of chalk dust on the tree.
>
> Next he would take the long-handled scoring axe, and score along down the line. That was to give the broadaxe something to bite on when he begun squaring a timber. He would take the broadaxe, and come down on the scored line at an angle that would take a thin slab off the side of the log, the same as you do at a sawmill. He would strike hard enough to carry the axe just about through; with a little up and down motion of the axe he would take off the slab down the log. You've heard about hewing to the line; this is what it was. It took a pretty good man to hew right to the line every time, and not strike off to one side. Gramp would hew to the line every time; I never seen him miss.
>
> Another thing about hewing with a broadaxe, the blade must go absolutely straight down. Everyone has a tendency to cut under. If you do that on each side of the log, the timber will be wedge shaped. So a good man like Gramp always strikes straight down.
>
> After he had hewed two sides, he would cut the limbs off the tree enough so that he could turn it over and hew the other two sides; up until then the limbs was what held the log steady for him. Gramp could square a timber in a surprisingly short time – not but a few minutes. A good man could do it fast enough to compete with a sawmill in some circumstances (Needham and Mussey, pp. 96-97).

The practice described as scoring "along down the line" is, if accurately recalled and recorded, an unusual and seldom used technique. Most sources referred to the nearly equivalent operation as "scoring to the line." In this case, the cuts were made at right angles to the line. It was the opinion of Gilles LaFrance that scoring along a line would require a significant number of gluts and iron wedges, more equipment than was available to the average hewer, to take off the slab as a single piece.



Axes, Adzes and Hatchets from Ralph Hodgkinson





From Eric Sloane

The more typical operation of hewing at the building site is described by a number of writers. Ralph Hodgkinson offered:

> The exact method of use of the broad axe has been controversial only because there is no single, "proper" way to use it effectively. However, the following steps are essential in its use: (a) A line indicating the plane of cut desired is snapped onto the log with a chalk line. (b) Notches are carefully cut to this depth at intervals along the log, using either a felling axe or the broad axe. (c) The log is supported at a height convenient for the method to be used, and secured against rolling or other motion. (d) In cutting, both hands are always used. (e) The heavy head and short handle (sixteen to twenty-four inches) make a short stroke most effective.
>
> With these facts in mind, at least three methods of use are readily understood. (a) With the log at such a height that for the normal arm-swing the blade cuts during the horizontal part of its arc, hence along the length of the log and its grain, producing a vertical plain surface. (b) …With the log higher and the axe cutting vertically downward across the grain. …With either of these two methods a parallel second face can be cut (without moving the log), by working from the other side of the log. (c) …With three guide-lines and either cross-grain or along-the-grain cutting, two adjacent faces can be cut without moving the log, each making an approximate 45° angle with the horizontal….

Without question, each of these methods was used by any competent axeman, depending on preference or necessity. When the work is well done, the surface produced by the broad axe is true, flat, even and smooth (Hodgkinson, pp. 3, 4).

Eric Sloane, agreeing that there was no generally accepted procedure, offered:

> As for the ancient chisel-edged broad axe, you walked alongside the log, working as you went. One man would swing horizontally (with the grain); another would hit straight downward; another would strike at an angle (Sloane, p. 16).

Sloane used annotated illustrations to describe the broader aspects of the hewing operation.

A description of hewing, provided by an experienced person, was given by Henry C. Mercer:

> According to Mr. Wilson Woodman, who, at the building of his barn near Wycombe, Bucks County, Pa., in c. 1860, helped hew the timbers, the fresh-felled tree, laid about knee high above the ground on underplaced cross strips, was first pared to the brown under-bark with the draw knife, then white chalk-lined on the brown for the hewing line. Thereupon, the workman standing on the log "scored it in" preferably for ease and speed, with a common felling axe, i.e. hacked into the log side with a succession of deep cuts, and split off the intervals nearly to the chalk line. Standing then on the ground with the log on his left hand and close to his left knee, he held the axe right-hand foremost with its flat side against the vertical log face, and hewed with both hands, not longways with the grain but diagonally downward across it (Mercer, p. 82).

Mackie added two interesting points:

> Scoring cuts should be 6 to 8" apart and very nearly to the depth of the cutting line….
>
> If the timber is very big, cuts may be made to the chalked line every 3 or 4 feet and the excess wood split off with wedges before finishing with the broad-axe…. (Mackie, p. 33).

Gilles LaFrance, who observed hewing by a "hatchet-man" in Nicabeau, a community in the Pontiac area of Quebec, noted some refinement of the scoring, splitting and smoothing operation. He observed that the hewer mounted the log, took a felling axe and rough notched at regular intervals. The notches were "V" shaped and deep. An ordinary chisel-edged broadaxe was taken up and with straight downward strokes the slabs were taken off. The hewer remounted the log and once more scored at regular intervals, but this time made only shallow (approximately ½ inch, 12 mm vertical cuts). A special chisel-edged broad axe, contoured and with straight handle, was then taken up and with strokes made horizontally (with the grain), the face was smooth.

Except for the description provided by Woodman (Mercer, pp. 81, 84), the techniques described are either conjectural interpretations of historic procedures or modern variants loosely based on historic techniques.

2.9 HANDLING

The handling of building materials, i.e. "putting up" palisade members, "laying up" horizontal logs and turning of members, is seldom described in any detail by contemporary writers. Only two descriptions have been located. The first was extracted from a letter written in 1834 describing the construction of a horizontal, round-log house:

> The ground has to be cleared, the logs have to be cut here and there to be carried on men's shoulders and raised to their places by mere human effort.... (Rempel, p. 79).

2.9.1 Raising

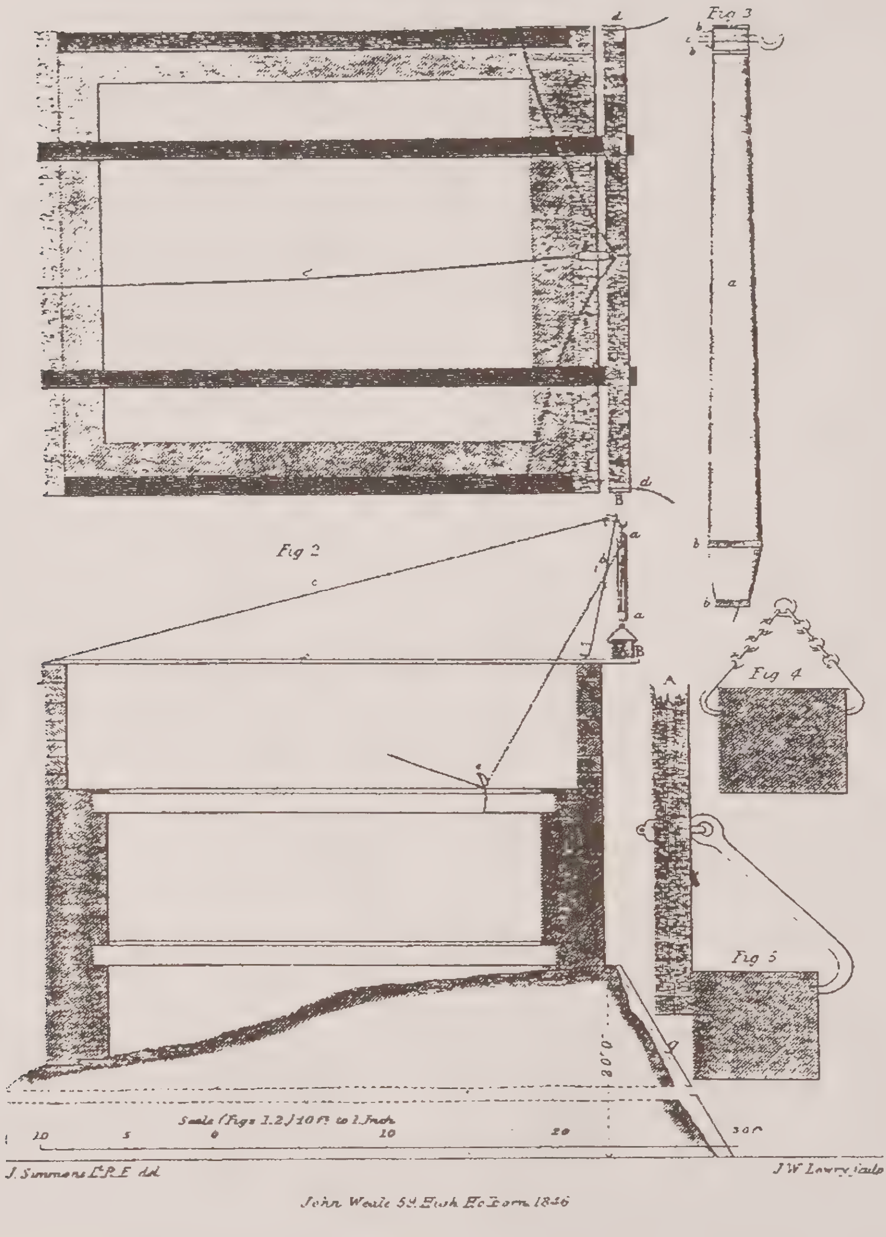
The second description comprises an entry under the head, "**Derricks** (**Sheers, &C**)," in the book *Aide-Mémoire to the Military Sciences*. The writer was Captain Simmons R.E., who supervised the raising of the "baulks" (squared logs) forming the walls of the second and third stories of a block-house built in 1841:

> **Derricks (Sheers, & C.)**
>
> The Derricks, sheers and gyn have one object in common, to find a point of fulcrum in space to which the pulley, in the shape of block and tackle, is to be applied; and this is effected by the above, on one, two and three legs, respectively.
>
> In the derrick and sheers, stability is given by guys; in the gyn they are unnecessary. Wherever these guys are used great attention must be paid to their being well fixed or being (when requisite) duly eased off: when accidents do occur from neglect in this respect, they are generally very severe.
>
> The applications of Derrick and Sheers about to be given are likely to provide for every probable occurrence, as the most extreme cases have been expressly selected; and these will be generally found in the practice of the Navy.
>
> **Derrick**
>
> An unusually bold application of this was made with perfect success in building the block-house at the confluence of Madawaska and St. John, New Brunswick, in 1841. In the operation, one particular advantage lay in the ease with which the whole apparatus was shifted from side to side of the building as required and in the rapidity with which the work proceeded; for although the workmen (colonial) were so unpracticed that they at first raised and placed only two logs (each 35 feet x 13 inches x 13 inches, weighing about 1 ton) per day, yet the walls of the second and third stories, each 11 feet high, were completely raised and framed by ten Canadian peasants in about a month; the last twelve pieces having been fixed in one day. Not a single accident occurred.
>
> *This application was made by Captain Simmons, R.E.
>
> It is to be observed, that from the height of the building and its inconvenient position and as the baulks (held on by the hand-guys...) were not allowed to swing to the rear, no front guys were used. The baulks were landed at first on the two ends of the loose plank... and afterwards turned over into their places by cant-hooks (*Aide-Mémoire, Vol. I*, p. 334).

Other methods for "laying up" horizontal logs are suggested by 20th-century writers. The utter simplicity of the principles and techniques described supports the view that they were frequently used in the past. In his report "The Log Cabin" which traces the steps in erecting a horizontal, round-log structure, Gilles LaFrance mentioned:

> The cabin would be erected close to a tree which would serve as a gin pole for raising the walls. It would later be cut down and its roots grubbed out.... Initially the logs were rolled up skids made of stout branches but very soon logs had to be lifted in place using a sling of rope hung from the tree which was left standing for the purpose, adjacent to a side wall (LaFrance, pp. 1-2).

The suggestion that the lower logs were sometimes "rolled up skids" is supported by similar 19th-century logging operations which involved the piling of logs at an assembly point (skidway) in the forest. Mackie described a refinement of the



The figures 1, 2, 3, 4 and 5 referred to in the article ***Derrick (Sheers & C.)*** *from Committee of the Corps of Royal Engineers (ed.)*

same method using block and tackle rather than cant-hooks (Mackie, p. 50).

> The cant-hook was four and a half feet long, terminating in a blunt "dog" with corrugations that bit into a log. This tool is used on rollways or skidways and in piling operations… Usually two or more men with cant-dogs are required to roll logs (Hughson and Bond, p. 65).

Another technique for raising logs which was used extensively in the logging industry and which may have good application in raising log walls was pointed out by Gilles LaFrance. The apparatus employed was called a "jammer." It was a "stone boat" or sled with a box filled with boulders in which were planted two large poles joined at the top. The poles were rigged as a "sheer" with a linch-pin and washer from which hung block and tackle. Dog-chains were employed to grasp the logs being raised. The apparatus was moved from place to place with a team of horses.

LaFrance observed apparatus of this description on property belonging to Spruce Falls Pulp and Paper in the Kapuskasing region of northern Ontario and on other properties in the Senneterre-Parent area of northern Quebec, the Baie Verte area of New Brunswick, and Kildonan, Manitoba.

Bryant described a "jammer" of slightly different design:

> Horse loaders or "jammers" are frequently used in the Lake States. These consist of a derrick and swinging boom mounted on a heavy sled, equipped with hoisting blocks and tackle. The jammer is drawn from one skidway to another by a team, and is placed directly behind the sleds to be loaded with the boom so placed that logs may be gripped on the skidway with tackle, elevated and transferred to the sleds. Power for hoisting is furnished by the team which transports the jammer (Bryant, p. 171).

No descriptions of the "putting up" of palisade members have been located.

2.9.2 Turning

A method for turning squared timber, once it had been raised to the top of a building using cant-hooks is included in the description of a "**Derrick**" discussed above.

A modern method of turning round logs which may have been based on a historical procedure, was described by Mackie. It involves angling and readjusting the log across a corner.

2.10 SETTING UP THE LOGS

Within the general category, palisade log work, are such specialized activities as stockade work, palisading and stave building construction. For the purpose of this article, the following definitions apply:

Stockage: refers to a solid barricade of upright timber, for intrenchments, redoubts, etc., the grade on either side of the barricade being more or less similar.

Palisade: in a permanent fortification is a solid barricade of upright timbers planted in the covert-way; in field fortification, a solid barricade of upright timbers planted in the ditch of a work.

Stave building wall: is a solid wall of upright timbers, the lower ends carried by a ground sill or buried in a trench, the upper ends linked by walers or a wall plate which in turn carries a roof.

2.10.1 Foundation

Support for freestanding palisade walling (stockade or defensive palisade) was generally provided in two ways. Individual vertical members were tenoned into a sill which was set in a trench and backfilled or individual vertical members were simply planted in a trench. Descriptions of the below-grade part of stockade work are quite abundant. An 1850 military text, on ordinary stockade-work, noted:

> To make this species of defence secure the timber should be sunk into the ground one-third of the height (*Aide-Mémoire, Vol. III*, p. 583).

Recognizing that stockades could be destroyed by artillery, the same text described a method of previously preparing a trench into which a timber could be let just prior to an assault:

> …narrow ditches or dykes, 12 or 14 inches wide and 4 feet deep, previously prepared in masonry and covered over with slabs of masonry until wanted. When an assault was apprehended, the timber for a stockade, kept on purpose in store, might be let into these crevices and well wedged together… (*Aide-Mémoire, Vol. III*, p. 584).

Historic descriptions are also found:

> ...our other men dug, a trench all around, of three feet deep, in which the palisades were to be planted. (Stotz, p. 43).
>
> ....
>
> They are to be set 3 ft 6 inches in the ground and to stand 7 ft 6 inches above excepting the faces and flanks of the Bastions 1, 2, 3,... (McConnell, p. 120).

The *Fort William Journal* (1836), reporting on the construction of the Fort William enclosure, provided the only documentation available of pointed pickets being placed on a sill (Halloran, p. 63).

The archaeological excavation of a prison stockade at Lower Fort Garry provided the following information on the trench profile:

> The trench varied in width from 2 ft. to 5 ft. and was 4.4 ft. deep with slightly sloping sides and a flat bottom (Chism, p. 28).

Descriptions of the below-grade part of palisade work are not nearly as abundant. Concerning the ordinary form of palisading, plainted in the covert-way, the *Aide-Mémoire to the Military Sciences*, (1850-1852) stated:

> ...the lower end is planted firmly 3 or 4 feet in the ground... (*Aide-Mémoire, Vol. III*, p. 39).

A type of palisading employing a timber sill was also described:

> The French planted admirable palisades in the ditches and rear of their works; each palisade was the rough stem of a young tree or the half of a larger one, fixed to a heavy beam four or five feet under ground (*Aide-Mémoire, Vol. III*, p. 40).

The actual work involved in excavating a narrow foundation trench, setting out the uprights (whether stockade or palisade), backfilling and compacting, is largely undocumented.

According to the *Aide-Mémoire to the Military Sciences*, sinking of trenches was usually done by teams of labourers using spade and pickaxe (*Vol. II*, p. 2). Considering the size of members being handled, it is presumed they were tipped into the trench by mere human effort. The research notes compiled by the RCMP for the reconstruction of Fort Walsh contained a description of the stockade; it is the only reference found where special note is taken of the backfill material:

> ...the logs being set in the ground three feet, packed hard with earth and rock and at the base this was covered with white mud, the stockade was kept plastered with white mud (McCullough, p. 249).

Reports of tests carried out by the Royal Engineers between 1840 and 1850 on branching stockades with bags of gunpowder consistently mentioned the ramming of the earth backfill:

> A trench 21 feet long, 2 feet wide and 3 feet deep, having been made, the timbers were planted in it at intervals and the soil, a stiff clay, was well rammed about them (*Aide-Mémoire, Vol. III*, p. 115).

Given that the tests were designed to simulate actual conditions, one suspects the process of ramming the backfill was commonly followed.

2.10.2 Floors

The only descriptions found concerning floors in stave buildings are those collected by D.C. Tibbetts for his publication, *The Newfoundland Tilt.* Of early tilts, he stated:

> Tamped earth provided the floor, and an open fire supported on some flat stones provided heat for cooking and for a minimum of comfort in winter (Tibbetts, p. 1).

Of actual Newfoundland tilts, Tibbetts was able to draw on descriptions of contemporary diarists:

> "The floor is made of longers, a flat rock forms the hearth...." "The floor is made with round studs like the walls, which are sometimes hewed a little with an adze." (Tibbetts, pp. 3, 4).

The actual work involved in preparing floors is largely undocumented.

2.10.3 Walls

The construction of stockades, palisades and stave-building walls took many forms. Detailed contemporary descriptions are rare. Most descriptions of early stockading are the results

of archaeological or historical research. This is the case with the main stockade built in 1802 to enclose the North West company post of Fort William. Researchers have concluded:

> ...the pickets would be about 17'-0" in height 12'-0" above the ground, 5'-0" buried, pointed pickets about 6" to 8" in diameter, King posts approximately 10' on centre a whaler about 2' from the tops of the palisade, mortised into the kingposts to which the pickets are fastened by means of two pegs (Halloran, p. 63).

Information on the stockade at Fort Battleford built in 1879 comes from a number of sources. In a report dated 1973, Campbell Innes, a historian, gave this account of the original structure:

> The stockade was built under the direction of Colonel Walker in 1879.... Then the logs were 8 inches in diameter and unpeeled. They were placed side by side 2-1/2 feet in the earth and above ground 10 feet, some say 8 feet. The earth was piled up on the inside a foot or two to strengthen the palisade (Innes, p. 101).

An alteration to the original stockade was noted by the *Saskatchewan Herald* in 1882:

> The top of the stockade at the barracks have been trimmed off, which greatly improves its appearance (Hildebrandt, p. 103).

Further changes to the Battleford stockade were noted in the commissioner's report of 1885:

> As you will be aware, the stockade was in a more or less dilapidated condition and my first care was to make it as strong as possible. I caused boards to be nailed all around the top and threw up a four post embankment against it on the inside. Through this breastwork I pierced portholes at suitable distance and so arranged them with sandbags as to secure the greatest possible protection for my men... (Hildebrandt, p. 103).

Research on the 1875 stockage which surrounded Fort Walsh brought to light the following undated memorandum prepared by D. Flemming:

> Fort Walsh was completely stockaded, this being built of heavy logs, fairly uniform in dimensions sic, approximately 10 to 12 inches thick, the Stockade stood from twelve to fourteen feet above the ground.... The stockade was strengthened on top by a squared timber being spiked in the inside, about three feet from the top. These logs were straight edged and would stop a rifle bullet of that day and age (McCullough, p. 249).

A stockade at Fort Mississauga, built in 1839 of squared timbers, was partially washed away in 1853 by the action of Lake Ontario. The estimate for its repair dated August 13, 1853 included a sketch labelled "Breastwork of squared Timber loopholed" and this note:

> Provision is therefore made for the repairs necessary to the breastwork with pine 12/16'.0" x 14" x 14" rough and fixed... (McConnell, p. 195).

On stockades, the *Aide-Mémoire to the Military Sciences* specified that:

> The construction may be either of square timber, musket-proof or of trees with two sides smoothed off with an axe, to make them meet, having small loopholes cut at the junction... (*Aide-Mémoire, Vol. III*, p. 583).

Elsewhere in the same text was the following description:

> Stockade-work may be made with the rough trunks of young trees, cut into lengths of 12 or 14 feet and averaging not less than from 10 to 15 inches in diameter. They should be firmly planted upright, in a narrow ditch, 3 or 4 feet deep, either close together or with intervals of a few inches for firing through. The interstices in either case should be filled up to a certain distance, with shorter pieces of timber to protect the men and the loopholes should be arranged with the precautions adverted to before.
>
> A banquette or step will generally be required on the inside; and a ditch and any other obstacle on the outside, that can be made in the time, will add to the difficulties of an assault (*Aide-Mémoire, Vol. III*, pp. 9-10).

Between 1840 and 1850 the Royal Engineers carried out a number of experiments in breaching stockades. A description of the experiments was published in the *Aide-Mémoire to the Military Sciences.*

Descriptions of palisading used historically in Canada are also found. The estimate for the main palisade at Fort George, 1799, had the entries:

- Four thousand feet running Oak 8 by 5
- Riband for Picketing…
- Six thousand Pickets 12 feet long 7 in. or 8 in. diam.
- One thousand feet cube of Cedar – Framing Post for Picketing (Desloges, pp. 142-43).

The construction of palisades is dealt with briefly by the *Aide-Mémoire to the Military Sciences*. It recommended:

> The palisade may consist of old trees, cleft in two, with the flat side spiked into a riband placed at the height of the covert-way, so that the soldier can rest his musket upon it; or it may be the young trees: in either case, the lower end is planted firmly 3 or 4 feet in the ground and the upper end connected by the riband of scantling or split timbers (*Aide-Mémoire, Vol. III*, p. 39).

An analysis of the fortification "thrown up in front of Libson" cited in the same text stated:

> The palisades in the ditches were mostly young fir-trees from 4 to 5 inches in diameter, roughly pointed and fixed 3 or 4 feet into the ground, with a riband very low down and, when the ditches were broad, much nearer the counter scarp than the scarp (*Aide-Mémoire, Vol. III*, p. 20).

The only descriptions of stave building walls which have been found are those collected by Tibbetts. In introducing the subject he stated:

> The walls of the original tilt consisted, essentially, of vertically arranged poles (sometimes fastened into a trench outlining the shape of the dwelling) with the interstices caulked with moss – a process known as "chinsing" or "chintzing" (Tibbetts, p. 1).

Tibbetts cited the papers of R. Bonnycastle (1842), of Julian Moreton (1863) and of Reverend William Wilson (1866):

> This dwelling, which was as lofty as a barn, was built of poles or sticks of very small diameter, placed upright, irregular together and braced every here and there (Tibbetts, p. 3).

> The four walls are made of the trunks of trees set close together perpendicularly.... No window is made or needed, the "chimney" admitting sufficient light.... No labour is spent in dressing any timber in the tilt; even the rind (bark) is kept on…

> The walls are formed of rough spruce sticks, called studs, of about 6 inches diameter, the height of the sides six feet and of the gables about 10 feet or 12 feet. The studs are placed perpendicular, wedged close together, and the chinks or interstices filled with moss (Tibbetts, pp. 3, 4).

2.10.4 Roofs

As with floors and walls, the only descriptions of roofs of stave buildings found were those collected by D.C. Tibbetts. Of early tilts, he stated:

> The roof consisted of small pole rafters covered with rinds (spruce or fir bark) with a hole left at one end to let in light and let out smoke (Tibbetts, p. 1).

Tibbetts was able to draw on descriptions of contemporary writers:

> The roof had been covered with bark and sods, and some attempts had been made originally to stop or caulk the crevices between the poles, both of the roof and walls, with moss or mud;…
>
> • • • •
>
> A small space is cleared of all wood except two opposite trees, growing at such a distance apart as is a suitable length for the house. A "longer" (ridge pole) is extended from one to the other of these trees, and seized to them at the proper height for the roof ridge.... Slender young trees are used for rafters, and these are covered with fir rinds to form a roof. ...and the chimney is simply a space left uncovered in one end of the roof.
>
> • • • •
>
> A ridge-pole passes longitudinally from the cables on which the round rafters are notched. These are covered with rinds, or the spruce bark which has been used during the summer as covering for the

> fish-piles. These rinds make the tilt water-tight. A hole is left in the rinds about four feet square, which serves the double purpose of a vent for the smoke and an aperture for the solar rays to permeate the dwelling (Tibbetts, pp. 3, 4).

The work of erecting a roof frame and placing the covering is undocumented.

2.10.5 Chinking

The chinking used for Newfoundland tilt structures was noted in the papers of R. Bonnycastle and Julian Moreton:

> The roof had been covered with bark and sods, and some attempts had been made originally to stop or caulk the crevices between the poles, both of the roof and walls, with moss or mud; but these substances had generally disappeared,....
>
> • • • •
>
> The chinks between the sticks of which the walls are made are caulked or as these people say, 'chintzed' with moss (Tibbetts, p. 3).

2.11 LAYING UP THE LOGS

To date, no substantial historical documentation of the steps for building a 19th century or earlier horizontal log structure has been located. On the other hand, 20th-century descriptions, of horizontal round log construction in particular, are fairly abundant. Probably the essential elements of the horizontal log building tradition were embraced by the 20th-century log builder. If so, then large portions of the 20th-century documentation can be taken as a record of the older traditions. For the purposes of this article, this assumption has been made.

2.11.1 Foundation

Many different foundation systems were used in the past for horizontal timber structures. A study focusing on one fairly small area of the country included this observation:

> **Foundation:** Four types appeared in equal numbers – log mud sill, randomly placed boulders, mortared stone and poured concrete. This graduation in quality indicates a series of improvements over an earlier method rather than a preference for a particular one. The first two methods listed are significant simply because of their presence and were probably common at the time of construction (Powter, p. 9).

Surviving estimates prepared by the Royal Engineers for a variety of military structures indicate a preference for the "stone foundation." The quantities of stone called for in three typical estimates suggest a footing depth of between 18 and 24 inches (Desloges, pp. 117, 127, 136).

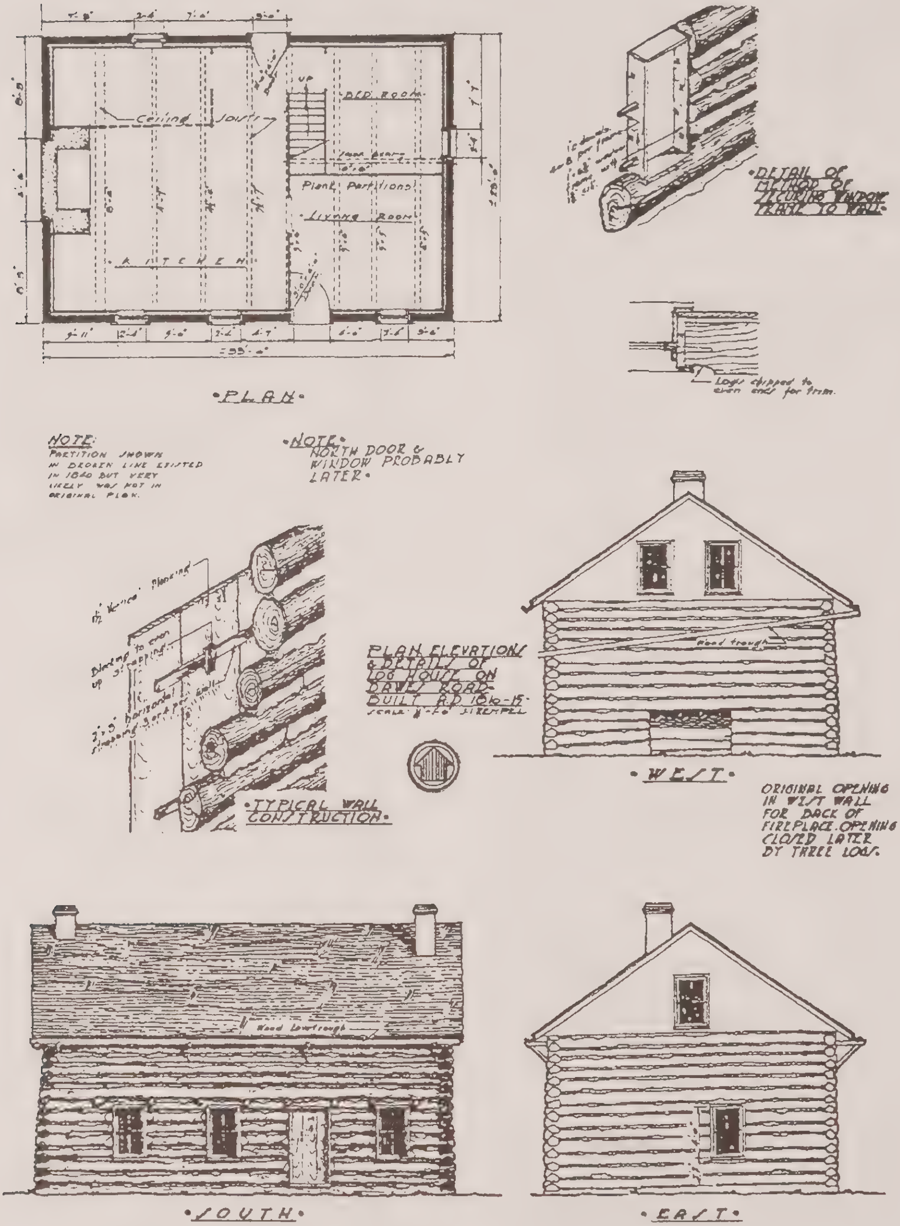
In his report, "The Log Cabin," Gilles LaFrance described a stone foundation or "curb" which was inserted beneath the log walls well after the closing in of the building (LaFrance, p. 5).

Some further foundation systems were suggested by Mackie:

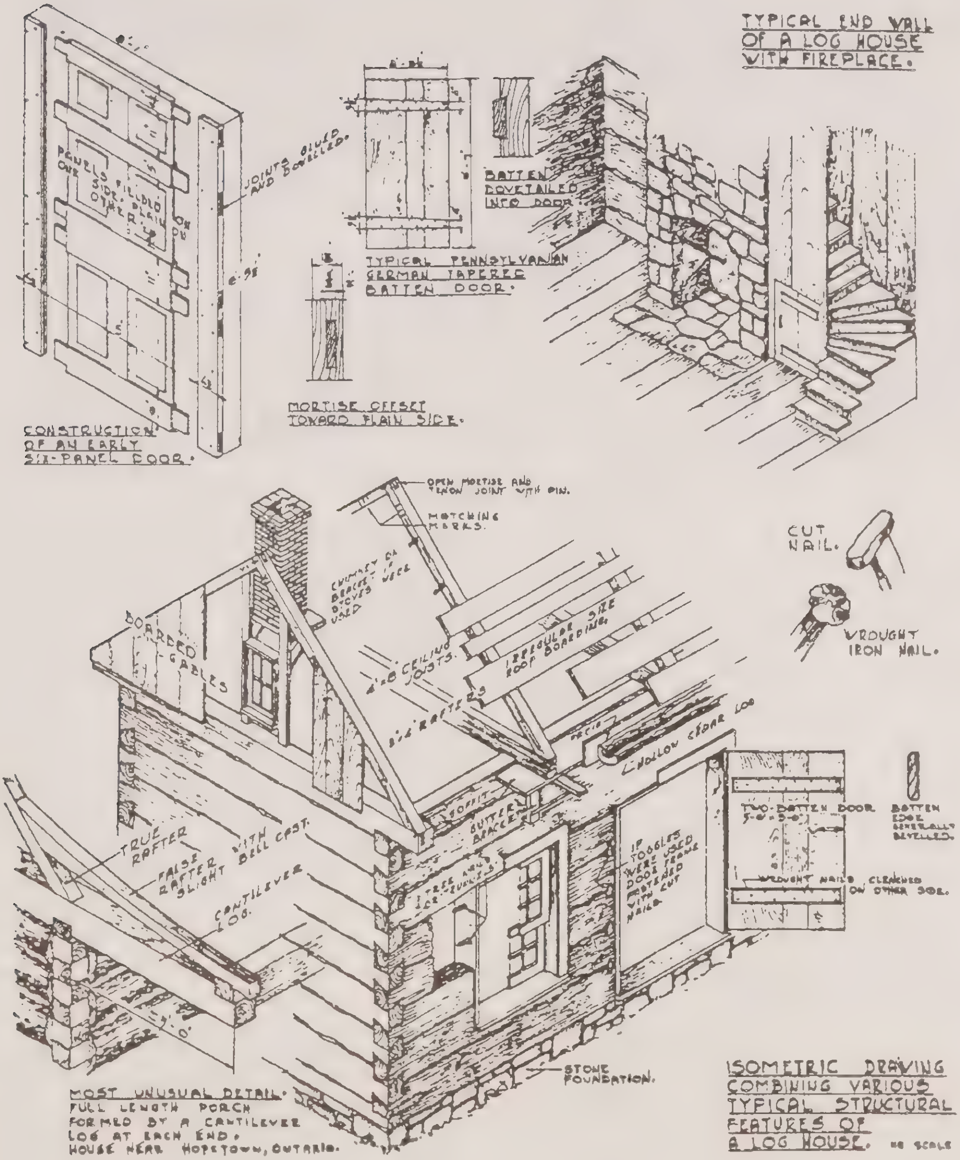
> His [the pioneer's] home probably had its first logs laid right on the ground or on small rocks (which he could carry) and which the weight of the building would soon drive into earth, so that it had no hope of surviving long. Or his house may indeed have been set up on a large boulder or cedar pilings at the corners but then, for lack of insulating materials for the floors, the pioneer would be forced to bank up all around the foundations with earth which did assure a few draught-free winters but guaranteed the quick deterioration of the logs as well (Mackie, p. 26)

Descriptions of the work involved in building many of these foundation types is scarce, perhaps because of their simplicity. Wicks, however, provided descriptions for timber piling and stone foundation piers:

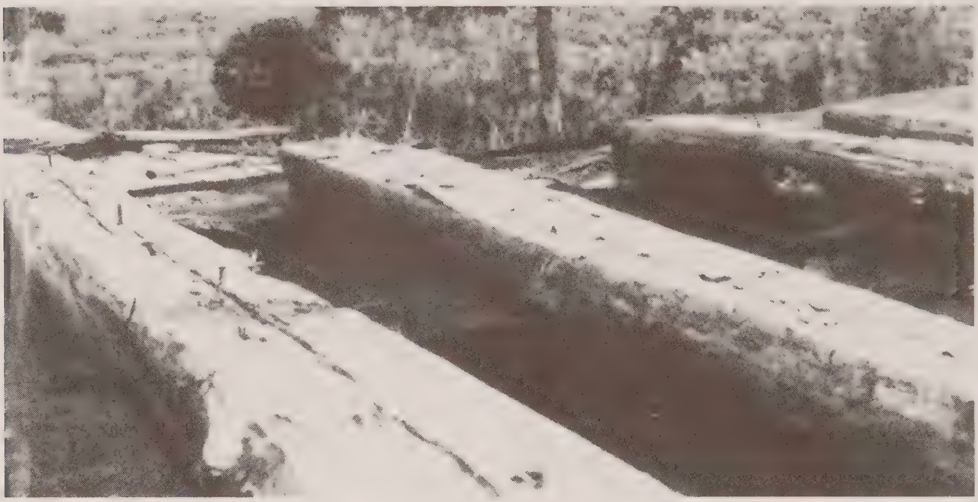
> If you use posts, select sound timber from ten to twelve inches in diameter, either hemlock, pine, tamarack or cedar. Cedar is the best. The hard woods will do, but they are not as durable.
>
> The posts should be cut about five feet long, and be placed in holes dug in the ground, at least three feet deep, or deep enough for the bottom end of the posts to rest on solid ground or rock. Place one post under each angle or corner of the structure and as many more under the sides and ends as are needed. For instance, if the building is rectangular, say twenty feet by twelve feet, then under the twenty feet side there should be two posts between the corners and under the twelve feet side one post. After the posts are in position mark one, say ten inches from the highest ground, and cut it off square; then from this mark its level on all the others and cut them off square, in order to begin your first tier of logs on a perfectly level foundation.



"De Boulins" or Horizontal, Round Log Construction from John I. Rempel



"Pièces sur pièces à queue d'aronde" or Horizontal Squared Log Construction from John I. Rempel



Lap-jointed sleepers have had top surfaces removed by a foot-adze from Wigginton

• • • •

> If stone is to be used for foundation piers, dig holes three feet or more in depth and not less than two feet in diameter. Fill these holes with small or broken stones, up to the level of the ground, care being taken that the stones are well settled together. Now get large cobble-stones and place them directly on top of the broken stone, chinking them up with small stone so that they will be well bedded in place. As with the posts, be careful that the cobble or cap-stones are high enough above ground and level to receive the first tier of logs (Wicks, pp. 10, 11).

Wicks and Fickes both recommended larger logs for sills. Fickes suggested a method of placement:

> First, the bottom logs should be set in place on opposite sides of the foundation. Hew a flat face of 2 to 3 inches in width on the under side of the log where it rests on the foundation, so that it will lay in place. Then place the bottom log on each end wall and accurately center it so that the inside face of all four logs is to the exact interior dimensions of the building. Dog the logs into place so they will not move while being marked for the corner notch (Fickes and Groben, p. 2).

The placing of "first logs" was detailed by Mackie:

> The first logs placed on the foundation will be on the side wall at right angles to the direction which the floor joists are to run. This will generally place them on the long side of the building. The butts should all face one way and the underside of each log is well flattened....
>
> The next logs should now be placed at right angles to these first ones, with the butts again all one way.... If the foundation is not built up at the ends, this space can be grouted in when the side logs are done (Mackie, p. 28).

2.11.2 Floors

At this stage in the construction, different tasks were performed depending on the flooring selected. The floor selected might be independent of the walls, such as described in *Metis Log Buildings in Saskatchewan*:

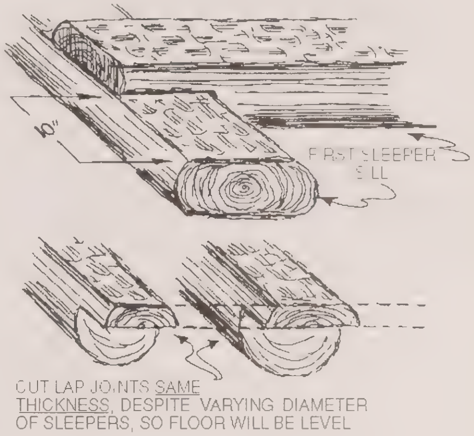
> House floor construction consisted of a floor and sub-floor system supported by joists on edge. The joists rested directly on the ground or on a wood sleeper pad. Floor systems were invariably independent of walls and foundation (Powter, p. 11).

If this type was used, further work on the first logs ceased. The task of building the wood slab floor on log sleepers which then followed was described by LaFrance:

> So far a floor of tamped earth was quite adequate except in the spring when the snow banked up around the walls, melted and dampened it to mud.
>
> A wood floor was a must as soon as you set up house in the cabin. There were still plenty of trees nearby and the method was known. The tamped earth of the first floor contained a high percentage of organic matter which could promote rot. This entire floor was removed to a depth of eight or ten inches.... The cavity was filled with sand and gravel or other inorganic granular fill. Logs were set down to provide a level bearing for the floor slabs to follow. And now it was back to the woods for more logs.
>
> These tree trunks were brought to the clearing and wedged in a tree crotch set in the ground to fix them above the soil for working. The felling axe was used to start splitting each log in two equal parts lengthwise. Iron wedges and wooden gluts were driven into the split to continue to part the two halves. These half-rounds were then fitted side by side using a hatchet to achieve a good straight edge butt. They were set on the mudsills rat tail fashion, that is, alternating wide and narrow ends until the entire floor was covered. These planks were spiked down to the mudsills to give a firm floor with an undulating surface. An adze was obtained to dress down these half-rounds and produce a flat floor. As they were exposed, spikes were driven further down to clear with the spruce on the poll of the adze or some other hammer (LaFrance, p. 5).

A similar floor, independent of the walls, was described by Rempel:

> The earliest form of flooring for a log house was of "cleft" planks, smoothed with an adze, and pinned to logs laid on the ground. One of the late pioneers recalls an old log inn as having "...the floor of loose split logs, hewn into some approach to evenness with an adze;...the hearth was the bare soil, the ceiling slabs of pine wood, the chimney a square hole in the roof...." As soon as a whipsaw was acquired or a saw mill erected, however, floor boards were cut rather than cleft (Rempel, p. 50).



If the floor system selected was one employing log floor joists notched into the sill logs, then a different set of tasks was required. Wicks said notches or "gains," should be cut as soon as the first tier of logs is laid and the floor sleepers installed (Wicks, p. 15). Mackie gave more detail in establishing level bearing points and installing the joists (Mackie, p. 28).

A more or less similar procedure for making and placing log joists and sleepers was put forward by Wicks:

> JOISTS – The sleepers, or joists, as they are more frequently called, are to be gained and tenoned into the bearing timbers... and so placed that they will have the shortest possible span. Those supporting the first floor may be left rough, as they do not show, but those in the second storey and ceiling will look best if they are peeled. Often these joists are made of hewn square timbers and with excellent effect....
>
> Select for the joist straight, sound trees. The logs for a twelve feet span or less should be about six inches in diameter; for a sixteen feet span eight inches in diameter; for a twenty feet span nine or ten inches in diameter. They should have one face flattened from end to end to make an even surface for the flooring

> to rest on. This face, in a twenty feet joist, should crown in the centre about two inches, and proportionately less for shorter spans; for when they are put in place they will sag sufficiently with their own weight and that of the floors, to make them level (Wicks, pp. 15-16).

2.11.3 Walls

Today there are many known methods of cornering. This is well illustrated by Mackie in *Notches of all Kinds, A Book of Timber Joinery*. The number of historic cornering methods illustrated by surviving structures is actually small. Rempel had the following to say:

> There were several methods of keying, of which the most common was the round notching of round logs with the ends projecting (usually not so far as in the Swedish manner) at the corners. Several variations were developed from this technique, culminating in the so-called dovetailing of squared logs (Rempel, p. 39).

He was able to provide Ontario examples of Pennsylvania keying, squared lay keying, dovetail keying, round notching or saddle notching, lap keying with a half-dovetail and wedge-shaped keying.

In his report, *Metis Log Buildings in Saskatchewan,* Andrew Powter stated:

> Considerable consistency of construction detail appeared in the study of both English and French areas. All external walls and outbuildings were always constructed of hewn logs, horizontally laid. In every case but one, the corner joint was made with a saddle-notched or dove-tail connection (Powter, p. 9).

A number of factors may have influenced the selection of a particular joint. The builder's knowledge of, or experience in, executing a particular notch and the time and manpower available were undoubtedly primary considerations.

> A shanty was, of course, considered as only a temporary building, every settler no doubt hoping to build within two or three years a more permanent log house or a frame, brick or stone house. Many log houses were also expected to have a relatively short life (Rempel, p. 22).

This being the case, it is doubtful if such criteria as structural soundness, ability to shed water readily and air infiltration, often used today to judge the adequacy of a particular cornering method, were foremost in the builder's mind.

Period descriptions of laying up a log wall are scarce. John McGregor in his book, *British America*, noted:

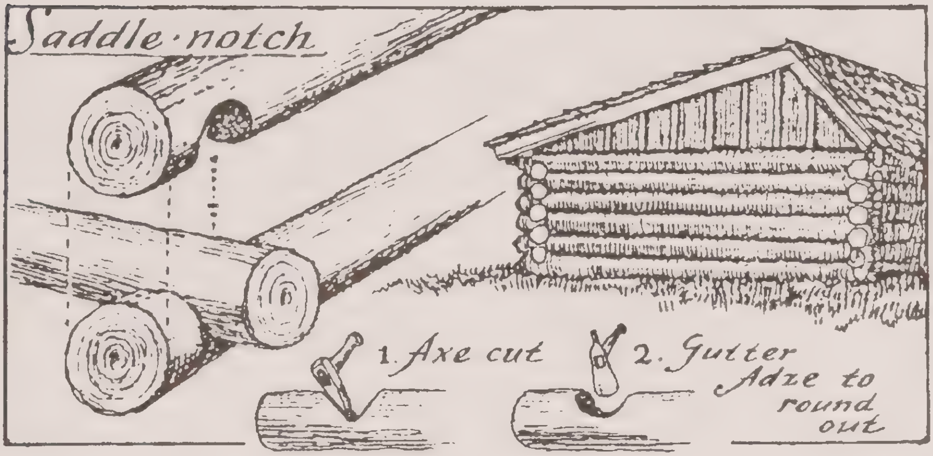
> Habitations which the new settlers first erect are constructed in the rudest manner. Round logs, from fifteen to twenty feet long, are laid horizontally over each other, and notched in at the corners to allow them to come along the walls within about an inch of each other. One is first laid on each side to begin the walls, then one at each end, and the building is raised in this manner by a succession of logs crossing and binding each other at the corners, until seven or eight-feet high (Rempel, p. 35).

In Mackie's description of erecting a round log wall with round notch corners, a lot of time was spent describing the execution of a lateral groove along the length of each log as a method of chinking (Mackie, p. 34). There is no evidence this detail was widely used historically. Another account of building using the round-notch, by Fickes and Groben, has the advantage of not referring to a lateral groove. As in Mackie's account, however, it detailed the use of wing dividers. Although this tool is of ancient origin, its use by period log builders has not been established.

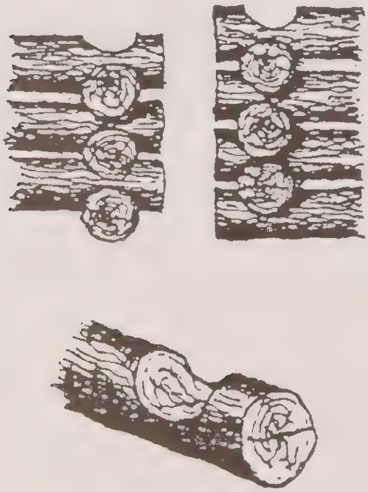
One important point on which Mackie and Fickes and Groben agreed was in the cutting of the notches in the underside of each wall log. It was the contention of LaFrance, supported somewhat by Rempel (p. 40), that in older structures, round notches are almost always found on the upper face of the logs, a detail which he believes was decidedly easier to execute by a small building team:

> Saddle notches are always cut in the top of the previous logs to receive a new unmarked log in the top of which two saddle notches would be cut. And so the walls were carried to the height of the builder's head (LaFrance, p. 2).

John I. Rempel, in *Building with Wood and Other Aspects of Nineteenth Century Building in Ontario*, pointed out that buildings with round notch corners frequently had tie-logs with dovetail keys to resist outward bulging of the walls (Rempel, pp. 43, 45).

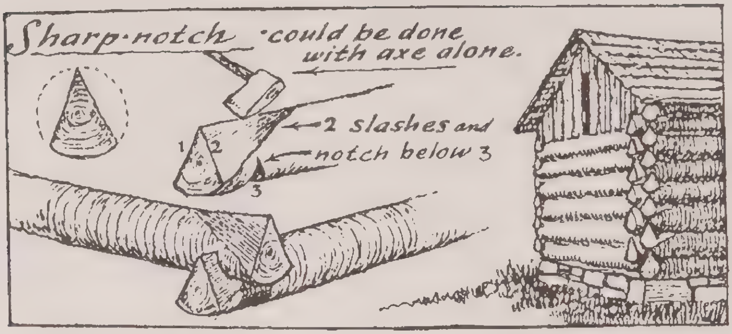


Saddle Notch, with Round Logs from Eric Sloane

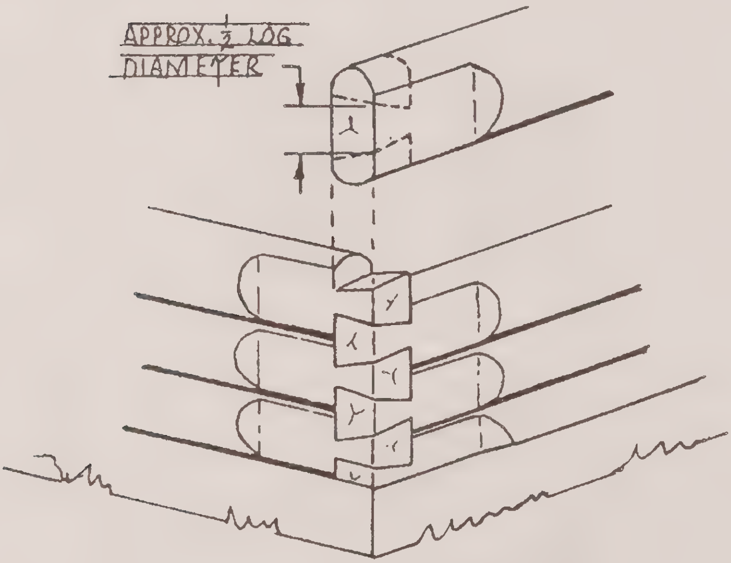


• Probably crudest form of cornering. Shanties, barns etc.

Inverted Saddle Notch, with Round Logs from John I. Rempel



Sharp-notch or Wedge-shaped Keying, with Round Logs, from Eric Sloane



Dovetail Keying with Round Logs from B. Allen Mackie

T. Ritchie, in *Canada Builds 1867-1967*, noted that tie-logs were needed where lap keying of the corners was selected. The tie-logs he described are, however, laid between opposite walls across the breadth of the building rather than in the special tier of wall logs described by Rempel.

> …for the neatest form of round log construction, a builder might cut the ends of every log square, then lay them with the bottom surface of each squared end on the top surface of the squared end of the intersecting log beneath it. Since in this method there was nothing to hold the intersecting sides to each other, builders frequently laid tie-logs across the front and back walls at storey height, notched into the space between the adjoining logs of those walls. In addition to their function as binding bars these logs also served as floor joists for the loft or second storey (Ritchie, p. 153).

A description of the cutting of a dovetail corner, in this case using round logs, was provided by Fickes and Groben:

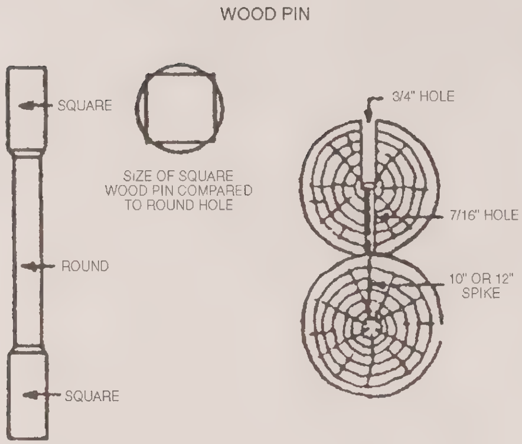
> The dovetail or box corner…is a strong corner and considerable experience is required in order to make a neat looking job. This type has several undesirable features:
>
> 1. The logs are apt to develop a wide crack because the corner is framed from the part of the log in which the least shrinkage occurs and
>
> 2. Since the logs are hewed down to form the corner, the wood has a tendency to collect and retain moisture which soon results in decay. Also, this corner detracts noticeably from the "loggy" appearance so characteristic and desirable in log structures (Fickes and Groben, p. 7).

A more extensive description was given by Mackie (p. 47).

Although few available sources discuss lining up the walls as they are layed up, Mackie suggested using a plumb or level on every second log or setting up a straight pole some distance from the building as a sight.

The problems of vertical as well as horizontal alignment were dealt with by Fickes and Groben:

> In laying the successive rounds of logs in the walls, several details must be observed to keep them lined up so that the top logs form a level seat for the roof framing. The corners should be kept as level as possible as each round is laid. This can be done by measuring vertically from the top of the floor joists, from time to time, as a check. A variation of 1 inch in height will not cause a serious difficulty.
>
> The height of the corners is regulated in two ways:
>
> 1. By increasing or decreasing the depth of the notch and
>
> 2. by reversing the top and butt ends of the logs when laying them in the wall.
>
> The logs should be fitted together as tightly as possible. In the case of somewhat irregular logs, it may be necessary to smooth off certain portions of the underside of the upper log to secure a tight fit. Only in exceptional instances, however, should this be done to the top of the lower log.
>
> The face of the logs on the inside of the building must be kept plumb, that is, in the same vertical plane. An ordinary carpenter's or spirit, level may be used, but a 6 to 8 foot plumb board is considered most satisfactory because of its greater length.
>
> The logs should be pinned together with a wooden pin or large spike. Spiking is done by boring a $^3/_4$ inch hole halfway through the upper log and continuing with a $^7/_{16}$ inch hole through the bottom half. Then drive a 10 or 12 inch spike into place or until it penetrates half the next log below. The spikes should be staggered in alternate rounds or tiers of logs. If wooden pins are used, fir or oak logs are preferable. Neither wooden pins nor spikes, however, offer interference to the settling of the walls.
>
> The spike method is easier and quicker and just as satisfactory as a wooden pin. The logs should be pinned approximately 2 feet from each corner and at each side of the window and door openings. For small structures, where the alignment of the walls is not so important, pinning may be eliminated, but it is essential to align larger buildings accurately in order to prevent individual logs from springing out of place (Fickes and Groben, p. 12).



"Pinning Log Together" from Clyde P. Fickes and W. Ellis Groben

2.11.4 Openings

The cutting and framing of door and window openings in a log structure is dealt with by a number of authors. Although somewhat similar in general principles, the techniques described are all quite unique. The single historical account belonged to John McGregor writing in 1833. Following a description of covering the roof and erecting a chimney, he noted:

> A space large enough for a door, and another for a window, is then cut through the walls.... When a door is hung, a window-sash with six or more panes of glass is fixed... (Rempel, p. 35).

Details of how the cutting was done and the openings framed are unfortunately lacking. The fact that the cutting of the openings was done so late in the building process did not escape the attention of Rempel. He considered this sufficiently interesting to make the comment:

> It will be noted that the walls were put together first without any regard to doors and windows. These were cut in afterwards from outside with an axe or a cross-cut saw, and were frequently charged as a separate 'extra' if the house were built on contract (Rempel, p. 35).

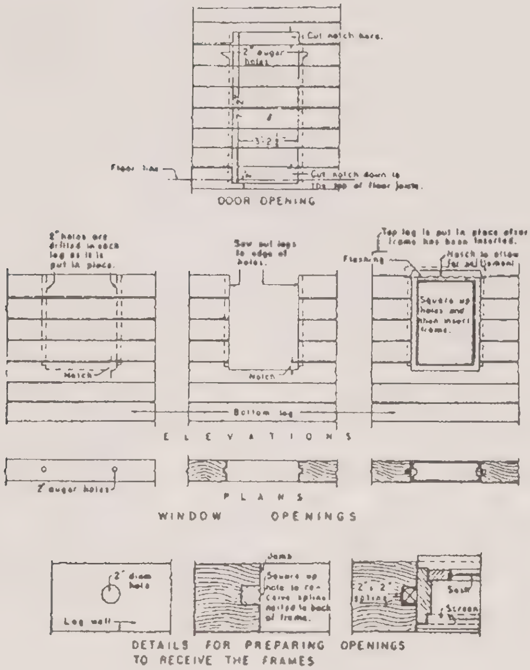
The comment that openings were cut "from outside using an axe or cross-cut saw" may stem from Rempel's first-hand observation of actual building details rather than documentary evidence.

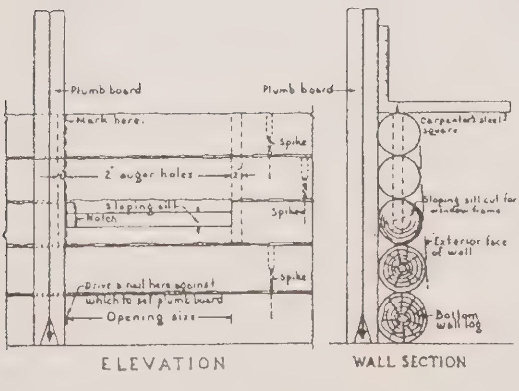
In his book, *Building With Wood and Other Aspects of Nineteenth Century Building in Ontario*, the caption to a detailed photograph of a rough opening reads:

> Openings in log walls were made by drilling several large auger holes at the top corners to provide entry for a saw to cut vertically and for an axe to split horizontally (Rempel, p. 36).

A method for cutting openings suggested by Wicks, writing in 1928, required no drilling. The uppermost tier pierced by individual openings was simply cut through before setting of the lintel log. Rough framing was dispensed with entirely:

> Make no particular calculations for the openings, unless it be to place a poor part of the stick where it will eventually be cut away. When you have reached the height of the windows and doors saw out the top logs of these spaces and lay the following tier. Then finish the openings by cutting the logs below the one already sawed out. This may be accomplished in the most satisfactory way by two men using a cross-cut saw. The openings being made, they will give you much more freedom to work in and about the building. The door and window frames should be ready to be put in place, so as to nail them fast, and thus secure the loose ends of the logs coming to the openings... (Wicks, p. 15).
>
> ....
>
> As soon as the first round of logs and the floor joists are laid in place, mark the location of door and window openings on the inside face. Next saw out the door openings and chop out the notch in the doorsill log to within an inch of the true or finished line. Leave final cutting of the openings to the exact dimensions until the window and door frames are to be placed in position, thus insuring a good finished wood surface. Also, determine the height of the openings above the floor line and mark them in figures on the bottom log for reference from time to time. The necessary cuts should be made in the log directly over each opening before placing it in position. When the log which carries the window frame is reached, a notch must be made for it as for the doors.
>
> To provide the necessary doors and windows, openings must be cut in the walls after the logs have been placed in position. As soon as a log in the wall is cut





"Cutting Window and Door Openings," top, and "Method of Marking Openings," bottom, from Fickes and Groben

in two, the problem arises of how to hold the loose ends in place. Also, the doors and windows require the proper kind of frames to insure airtight closure between the latter and the ends of the wall logs. The most practicable and satisfactory method is to frame a vertical notch in the ends of the wall logs, into which can be fitted a spine attached to the back of the jamb or sidepieces of the door and window frames. This method of framing holds the wall logs in place, allows them to shrink and settle without hindrance and makes a weathertight joint between them and the door and window frames. The vertical notch in the end of the wall logs may be framed by boring a 2-inch auger hole in each log as it is laid in place. The hole should be located so that, when the wall logs are sawed out for the opening, the saw cut passes down through the edge of the hole nearest the opening. It is then a simple matter to frame the notch to take the spine. The inside face of the notch can be left rounded and the spline chamfered to fit. To keep the holes in line from log to log, use the plumb board (Fickes and Groben, p. 14).

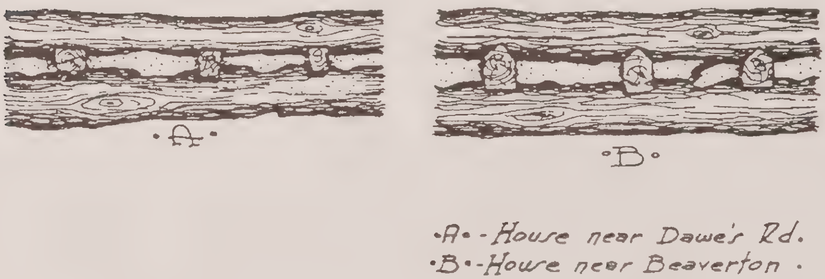
Mackie described a method for cutting both temporary and permanent openings not unlike that of Fickes and Groben, but suggested augering holes vertically, 4 in. beyond the sides of the opening to later help make the mortise grooves for a key (Mackie, p. 53).

2.11.5 Second Floor Joists and Ceiling Beams

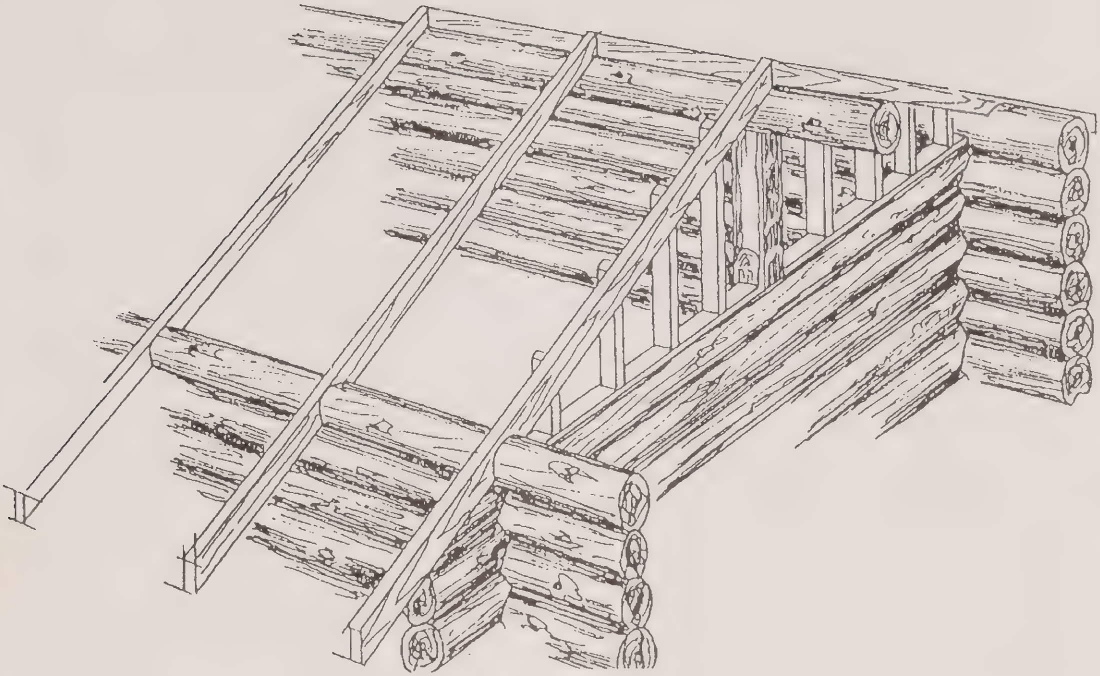
Descriptions from any period, including the present, of the techniques for making and placing second floor joists are scarce; this is no doubt a reflection of the small number of $1^1/_2$ and 2 storey horizontal timber structures that were actually built. Wicks, one of the few writers to acknowledge their existence, stated simply:

> When at the height of the second floor, frame and place the floor joist and again continue with the laying up of logs to the proper height for receiving the rafters… (Wicks, p. 15).

Descriptions of the procedures involved in placing ceiling joists are less than comprehensive. Mackie stated simply:



Two Common Ways of Seating the Joists. "Methods of Securing Ceiling Joists" from John I. Rempel



Framed Gable End from B. Allan Mackie

> Ceiling joists may be placed in a manner similar to floor joists. Square hewn ceiling joists give a good appearance, but consider carefully whether or not your plan requires a ceiling…it may simply be hiding your carefully selected ridgepole (Mackie, p. 60).

Rempel, an observer of 19th-century building practice, on the subject of ceiling joists stated:

> The smaller houses would, of course, have no ceiling. If ceiling joists were used, the space under the roof was used as storage. Ceiling joists invariably spanned the full width of the house, and the ends generally rested on the sixth or seventh log, depending on the diameter of the trunks. The most common ways of seating the ends of the joists in the wall were either to fit a squared end into a square notch cut on the log carrying the joists or to cut the top of the ends to a wedge shape which fitted in a groove cut into the under side of the log resting immediately on the joist ends (Rempel, p. 53).

2.11.6 Gable Ends

Documentary and iconographic evidence indicates that the gable ends of horizontal log structures were treated in one of two ways: the horizontal wall members were carried up to the ridge; or (more commonly) the triangular space was framed and boarded. The survey of Métis log buildings in Saskatchewan, carried out by Andrew Powter in 1977, identified numerous horizontal log structures with log gables.

A 1785 estimate for two log houses contained the instruction:

> …The Gables Ends to be Studded and Weather-boarded with Rough Boards (Rempel, p. 69).

Period construction of a log gable was described by LaFrance thus:

> Log gable ends were built up to give a peak roughly ninety degrees wide. Log pieces of the gable were pegged together and the ends were dressed off, to the proposed underside of the roof, with an axe or hatchet. A ridge pole was pegged on top of the two gable end walls… (LaFrance, p. 2).

Mackie suggested pinning the gable end logs with two-inch (50 mm) square pegs driven into two-inch (50 mm) auger holes. He also described the setting of purlins which are notched into the log below so that the ends of the gable logs are not severed when the roof slope is cut (Mackie, p. 56).

2.11.7 Roof Framing

A number of roof framing systems were used in horizontal log structures. The most common were:

- the couple roof (two inclined rafters, the upper ends joined or abutted against a ridge member, the lower ends seated on the wall plate)
- the couple close roof (similar, except the lower ends are joined by a tie-beam)
- the purlin roof (rafters, the lower ends seated on the wall plate, the middle supported by a purlin and the upper ends carried by the ridge member)

A purlin roof without rafters, designed specifically for "long shakes" but which could easily accommodate other roof finishes, was described by Fickes and Groben:

> Where the effect of a considerable overhang is desired, an eave purlin log may be used to support the projecting shakes…. To support 30 to 36 inch long shakes having a 6 inch lap, the log purlins should be spaced at approximately 24 inch intervals. In regions of heavy snows, the eave log may be placed slightly forward to help support the overhang or an additional eave log may be placed in position…. The gable logs should be run up at the same time as the roof logs and both rigidly framed together (Fickes and Groben, p. 23).

A description of framing a couple close roof was given by the same authors:

> The framing for a shingle roof, whether of sawed material or round poles, is done in the same way as that of a frame building. The top log on the wall may be cut with a flat seat for the rafters to rest upon or notched out to receive them. The gable ends may be run up with the logs, which is preferable for architectural appearance or framed like the gables of a frame structure and then covered with wood siding, shingles or shakes.
>
> The shingles may be laid over sheathing boards in the usual manner or on shingle strips placed across the roof rafters, parallel with the ridge and exactly spaced to receive them, commonly known as "barn-fashion."
>
> The particular method to be followed in framing the eaves depends largely upon their protection (Fickes and Groben, p. 22).

Wicks provided a description of building a couple roof:

> The rafters should be selected and flattened in the same manner as the joist, frame them on to the plate-logs at the bottom end… and bevel them at the top end to suit the pitch of the roof.
>
> Place a ridge-board or pole between the rafters at the top end. Raise the gable rafters first, as they will serve as guides in placing the rest. After these are in position, unless the work is well laid out, it may be found necessary to cut off or block up the intervening rafters a little to fit the ridge-board or pole and thus make a perfectly straight roof line. Place the rafters from two to three feet apart. Pin or spike them at the foot to the log-plates and at the top nail them to the ridge-board or pole (Wicks, p. 18).

The choice of notch or seat for common rafters is a subject dealt with by Mackie in *Notches of All Kinds, A Book of Timber Joinery.*

2.11.8 Partitions

A variety of interior partition types were used historically in the horizontal log structure. One commonly used type was

composed of plain, rough sawn boards standing vertically, butted together (with or without muslin and paper covering). Examples of this type survive in the Robert Service cabin and West's machine shop buildings in Dawson, YT. In some cases, batten strips were applied over the joists; a description of the construction of this type was provided by Wicks:

> Use unmatched, planed or not planed boards and nail a vertical piece or batten about two inches wide and one inch thick over the joint.... In this case the boards should be nailed firmly at top and bottom, or, if it should be desirable to build so that the joint shrinkage may be taken up...then nail one batten to the edge of each board only, and proceed as there directed (Wicks, pp. 23, 24).

In place of batten strips, one face of a plain plank partition was sometimes given a board lining. An estimate drawn in 1796 for the centre blockhouse at Fort George had the entries:

> Two thousand Nine hundred & twenty inch boards – upper covering to 2nd floor Upper floor, Partitions, Necessaries & ca...
>
> Two hundred ½ inch Boards lining Partitions of Officers Quarters & ca. (Desloges, p. 118).

One definition of "lining" given by *The Illustrated Glossary of Practical Architecture*, published in 1853, was:

> ...the inside of walls are sometimes lined to a height of 4 or 5 feet from the floor (Brees, p. 254).

Unfortunately no detailed description of building a lined, plank partition has been located.

Match board partitioning was certainly common, especially in the last quarter of the 19th century. This is a point made by Rempel:

> Interior partition walls were generally of planks set vertically; as a rule these planks were tongue-and-groove with a beaded edge (Rempel, p. 51).

Examples can be seen in the Riel house, St. Vital and in the men's house, Lower Fort Garry. Plain edge, centre bead and V-joint profiles were all used. A description of building a match-board partition was provided by Wicks:

> INSIDE PARTITIONS. – These are made in a variety of ways and are placed after the flooring is laid. The simplest and perhaps the most satisfactory manner of making such a partition is with matched boarding....
>
> If a particularly smooth job is wanted, have the boarding planed on both sides before leaving the mill. A cleat about one inch square with the corner taken off should be nailed to the ceiling or to ceiling beams at the top, and to the flooring boards at the bottom, care being taken that they are in line. The matched boards are then cut the proper length and placed in position, driving the matching as tightly together as possible, but without nailing, save an occasional tack nail, which should be taken out at completion. Place on the opposite side of the boarding the same sort of a cleat as mentioned above, and the partition is completed. When partitions are built in this way the cracks which occur from shrinkage of boards may be entirely corrected by driving the boards together and putting in an additional piece to fill out the space at the side of the room. If, however, the matched boarding is not over five inches wide, and fairly dry, it is safe enough to use but one cleat and toe-nail to the flooring from the opposite side of the partition, and so also at the top, unless it should be found convenient to nail to the side of a timber or joist (Wicks, pp. 22, 23).

Log partitions, oddly enough, were not that common. The explanation may lie in a statement made by Rempel:

> In some instances, however, an owner would insist on log partitions, but this was an "extra" for which he had to pay. Abner Miles charged Wm. Jarvis £8 for such partitions... since the logs have to be keyed into another wall at right angles for stability (Rempel, p. 51).

The 1794 estimate referred to by Rempel had the entries:

> Log partitions 8.0.0.... The partitions in the Lower Story to be Logs Six Inches thick and to be doughtaled at each end (Rempel, p. 74).

Fickes and Groben described the following method of building a log partition:

> If the log-construction plan is to be carried throughout the structure by using interior log-wall partitions, these

Log Cabin Showing Chinking and Daubing (Wigginton, p. 105)

should be laid out and framed in and the door openings cut in the same manner as previously described for exterior walls. If a log partition comes at a place in a cross wall where it is not considered desirable to have the log ends project into the room beyond the opposite face of the wall, they may be sawed off flush with the face of the cross wall. This will not weaken the joint since the logs are both pinned and locked in place (Fickes and Groben, p. 23).

2.11.9 Chinking (and Daubing)

References to a variety of chinking types are found in 19th-century documents. The following referred specifically to horizontal log constructions:

> The joints between the logs are then made weather-tight by a stuffing of clay or wattles, sallows or small branches of soft wood; and these joints are then lined with laths or the whole interior boarded, if 1 inch (25 mm) boards can be had, which is preferable (*Aide-Mémoire, Vol. II,* p. 258).
>
> • • • •
>
> The seams are closed with moss or clay....
>
> The spaces between the logs were chinked or "stubbed" with wooden wedges, stones, branches, or simply straw mixed with mud or clay. The less care that went into the selection of the logs, the more chinking that had to be done (Rempel, pp. 35, 48).

Both Rempel and Shurtleff, author of the book *The Log Cabin Myth*, pointed out that chinking of round log construction was in many instances a two step process:

> ...in the log cabin era, "chinking and daubing" was a familiar expression. You "chinked" the interstices between the logs with moss, chips, split oak or what-you-will and kept them in place by a "daubing" of clay or plaster (Shurtleff, p. 103).
>
> • • • •
>
> The interstices [between the logs "either round or squared"] were wide enough to require chinking with wedges of wood...as well as clay or lime mortar (Rempel, p. 15).

The following references to the chinking of squared log construction were located:

> ...the said Jarvis is to find the Lime to make the Mortar to lay said between the Logs...
> (Rempel, p. 74).
>
> • • • •
>
> I therefore decided on a good log house, raised on a stone foundation to protect the lower logs and the logs hewn square and bedded in mortar; it may afterwards be plastered or papered inside and roughcast outside (Rempel, p. 80).

The caption for an illustration used by Rempel to illustrate chinking in an 1832 squared log house reads:

> A type of chinking which is quite rare in Ontario. Note the carefully cut wooden wedges, tapered on opposite sides and driven up one against the other to seat them securely between the logs. This forms an excellent key for the plaster chinking, both on the inside as well as the exterior (Rempel, p. 45).

No contemporary descriptions of the techniques used in chinking historic horizontal log structures have been found. The earliest 20th-century description of chinking a round log structure was provided by Wicks:

> CAULKING. – to ensure a perfectly storm-proof cabin, the spaces between the logs must be caulked; but defer this as long as you can, so that the logs will get as dry as possible. This work you will be obliged to repeat the second season, and so it is well to leave the general finish of the cabin until the following year, at least if part of the finish should go over the face of the logs. The caulking is done with oakum or moss forced into the joints from both sides of the logs with a wooden, wedge-shaped chisel, struck with a mallet (Wicks, p. 34).

A description of the techniques of making and placing "cedar wool" in a round log structure is provided by LaFrance:

> The bark of cedar trees felled to make the roof is still in the swamp; it is time to drag it out and beat it to a pulp over a stone using the froe club. This pulpy, stringy cedar wool once dried in the autumn wind made a fine chinking material which did not harbour insects or worms as mosses did. It was tamped by hand into every crevice and crack and firmly packed to keep out wind and snow (LaFrance, p. 4).

3.0 BIBLIOGRAPHY

Brees, S.C. 1853. *The Illustrated Glossary of Practical Architecture and Civil Engineering: Comprising the Theory and Modern Practice, with the Subjects of Office and Field Work.* L.A. Lewis, London.

Bryant, Ralph Clement. 1914. *Logging, The Principles and General Methods of Operation in the United States.* John Wiley & Sons, New York.

Burns, Robert Scott. ed. 1867. *The New Guide to Carpentry, General Framing and Joinery; Theoretical and Practical.* M. Gready, Thomas & Niven, Glasgow.

Canada. National Archives. *Wm. Douglas Lane Papers, II A - Business Documents (1835-1875).* MG A40.

Chism, James V. 1972. *Excavations at Lower Fort Garry, 1965-1967; A General Description of Excavations and Preliminary Discussions.* Occasional Papers in Archaeology and History. No. 5. Canadian Historic Sites, Ottawa.

Corps of Royal Engineers, Committee of the, eds. 1850-52. *Aide-Mémoire to the Military Sciences.* 3 vols. John Weale, London.

Csizmazia, J., et al. 1966. *Analytical Procedures for Developing Log and Tree Quality Classification Systems.* Publication No. 1144. Department of Forestry, Ottawa.

Desloges, Yvon. 1977. "Structural History of Fort George," Manuscript Report Series No. 189. Parks Canada, Ottawa.

Dilworth, J.R. 1964. *Log Scaling and Timber Cruising.* Revised edition. OSU Book Stores, Corvallis, OR.

Dixon, L.B. 1956. "The Birth of the Lumber Industry in British Columbia," BCIMA publication, reprinted from *British Columbia Lumberman,* Vancouver.

Fickes, Clyde P., and W. Ellis Groben. 1973. *Building with Logs.* Facsimile repro. of 1945 edition. Bulletin, United States Forest Service. Shorey Book Store, Seattle.

Forest Products Laboratory. 1960. *Making Log Cabins Endure, Suggestions on Construction, Log Selection, Preservation, and Finishing.* Report No. 982 revised. Forest Products Laboratory, Madison.

Gwilt, Joseph. 1891. *An Encyclopedia of Architecture, Historical, Theoretical, and Practical.* 4th edition revised. Longmans, Green & Co., London.

Halloran, Joan. 1974. "Wooden Forts of the Early Northwest: Fort William," *Bulletin of the Association for Preservation Technology.* Vol. 6, No. 2, pp. 39-81. Ottawa.

Hildebrandt, Walter. 1978. "Fort Battleford: A Structural History Volume I: Building Reports," Manuscript Report Series No. 252. Parks Canada, Ottawa.

Hodgkinson, Ralph. 1965. *Tools of the Woodworker: Axes, Adzes and Hatchets.* Technical Leaflet 28. American Association for State and Local History, Nashville. Quoted material reprinted by permission: Copyright © 1965, AASLH.

Hughson, John W., and Courtney C. Bond. 1965. *Hurling Down the Pine.* 2nd edition revised. Historical Society of the Gatineau, Old Chelsea, PQ.

LaFrance, Gilles. 1978. "The Log Cabin," Manuscript on file, Restoration Services Division. Engineering and Architecture Branch, Ottawa.

Mackie, B. Allan. 1977. *Notches of All Kinds, A Book of Timber Joinery.* Canadian Log House, Prince George, BC. Quoted material and illustrations reprinted with permission: © Canada 1971 and 1972.

__________. 1977. *Building with Logs.* 6th edition. B. Allan Mackie and Ida Mary Mackie, Prince George, BC.

__________. 1979. *Building with Logs.* 7th edition. Log House Publishing Co. Ltd., Pender Island, BC.

McConnell, David. 1977. "A Study of the British Military Buildings at Niagara-on-the-Lake, 1814-37," Manuscript Report Series No. 191. Parks Canada, Ottawa.

__________. 1977. "A Study of the British Military Buildings at Niagara-on-the-Lake, 1838-71," Manuscript Report Series No. 226. Parks Canada, Ottawa.

McCullough, A.B. 1976. "Fort Walsh: Documents Relating to its Structural History," Manuscript Report Series No. 174. Parks Canada, Ottawa.

Mercer, Henry C. 1951. *Ancient Carpenters' Tools, Together with Lumberman's, Joiner's and Cabinet Maker's Tools in Use in the Eighteenth Century.* 2nd edition. Bucks County Historical Society, Doylestown, PA.

Muller, John. 1756. *A Treatise Containing the Elementary Part of Fortification, Regular and Irregular.* 2nd edition. J. Nourse, London.

Needham, Walter, narrator and **Barrows Mussey**, recorder. 1966. *Grandfather's Book of Country Things.* Paperback Library, New York.

Peterson, Charles E. introduction by. 1971. *The Rules of Work of the Carpenter's Company of the City and County of Philadelphia 1786.* Pyne Press, Princeton, NJ.

Powter, Andrew. 1977. *Metis Log Building in Saskatchewan.* Restoration Services Division. Engineering and Architecture Branch, Ottawa.

Radford, William A., and Alfred Sidney Johnson, eds. 1909. *Radford's Cyclopedia of Construction.* 12 vols. Radford Architectural, Chicago.

Rempel, John I. 1967. *Building with Wood and Other Aspects of Nineteenth Century Building in Ontario.* University of Toronto Press, Toronto.
Quoted material and illustrations are reprinted with permission.

Richardson, A.J.H. 1973. "A Comparative Historical Study of Timber Building in Canada," *Bulletin of the Association for Preservation Technology,* Vol. 5, No. 3, pp. 77-102. Ottawa.

__________. 1976. "A Further Note on French-Canadian Roof-Cover and Timber Walls," *Bulletin of the Association for Preservation Technology,* Vol. 8, No. 1, pp. 61-69. Ottawa.

Ritchie, T., et al. 1967. *Canada Builds, 1867-1967.* University of Toronto Press, Toronto.

Shurtleff, Harold R. 1967. *The Log Cabin Myth, A Study of the Early Dwellings of the English Colonists in North America.* Reprint of 1939 edition. Peter Smith, Gloucester, MA.

Sloane, Eric. 1975. *A Museum of Early American Tools.* Ballantine Books, New York.
Illustrations reprinted with permission.

Stotz, Charles Morse. 1974. "The Reconstruction of Fort Ligonier, the Anatomy of a Frontier Fort," *Bulletin of the Association for Preservation Technology,* Vol. 6, No. 4, pp. 2-44. Ottawa.

Tibbetts, D.C. 1968. *The Newfoundland Tilt.* Reprinted as Technical Paper No. 296. Division of Building Research. National Research Council of Canada, from *Habitat,* Vol. 11, No. 5, 1968. Ottawa.
Quoted material reprinted with permission: National Research Council of Canada.

White, Patrick C.T., ed. 1958. *Lord Selkirk's Diary, 1803-1804, A Journal of his Travels in British North America and the Northeastern United States.* Champlain Society, Toronto.
Quoted material reprinted with permission of the Champlain Society, Toronto, Canada.

Wicks, William S. 1928. *Log Cabins and Cottages, How to Build and Furnish Them.* 9th edition. Forest and Stream, New York.

Young, Richard J. 1973. "A Comparative Report and Catalogue of Blockhouses in Canada," Manuscript Report Series No. 155. Parks Canada, Ottawa.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

8.1

PERIOD JOINERY

DOOR MAKING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: KEN ELDER

CONTENTS

1.0 INTRODUCTION

It is the aim of this article to bring together doormaking references, so that they may be read sequentially from the initial selection of timber to the finishing of the completed door.

For the sake of simplicity, only those references on doors with plain panels (not raised), frames with the edges left square and through mortise and tenon joints have been chosen.

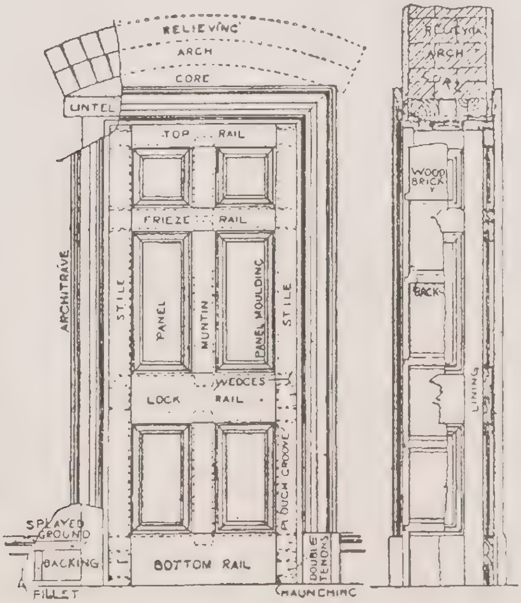
The apparent complexity of making a panelled door is misleading. Many writers have stated that it was not a difficult joinery skill:

> A door is a simple piece of paneled work, but the great variety of form and arrangement of its panels, and the enrichment of its mouldings, together with the conditions arising from its method of opening or closing require it to be even more securely framed and glued than a wainscot or other piece of fixed paneled work (ICS Reference Library, p. 23).

> The subject of the present chapter [a four-panelled door] is, perhaps, easier to make than any other variety; but, at the same time, it should be done properly, if a good result is to follow (Talbot, p. 25).

The techniques of building a custom, hand-crafted, framed and panelled door is in danger of becoming a lost art. In the name of economy and in order to compete with mass produced, machine-made doors, joiners ceased to build and hang custom, hand-crafted framed and panelled doors as early as the 1870s in Canada.

Descriptions of the steps followed in building a typical four-panelled, through mortise and tenon joined door are found in a variety of instructional texts, manuals, course notes and unpublished manuscripts, few of which are readily available. No single source has been found which follows the process from beginning to end.



A Door with Jambs and Linings Complete. The details for constructing and fastening in place are all shown. Each member of the door is named, also base and grounds (Hodgson, Vol. 2, p. 299)

2.0 DEFINITIONS

Dressed down: Planed (Scott, p. 112).

Firmer [Chisel]: An ordinary carpenter's chisel. Firmer chisels vary in width from 5/8 in. to 2 in. long and thin in the blade and are suited for the rougher work of the carpenter and joiner (Ward, Lock & Co., Ltd, p. 1.93).

Gauge: Mortise gauge. A marking gauge with two marking points, one of which is movable. It is used for marking out mortises and tenons (Scott, p. 227).

or

Marking Gauge: A beechwood bar with a steel point near one end projecting at right angles from it and a hardwood block sliding along it which can be locked at any point along the bar. It is used for marking lines parallel to the face of the wood which the block travels along (Scott, p. 217).

Haunched Tenon: A tenon which is narrower at the tip than at the root. The wider part is called the "haunch" or "hauncheon" (Scott, p. 172) "haunchion" (Kelsey, p. 176), "haunching" (Talbot, p. 25). Haunchions may be bevelled or square and allow a mortise to be kept back from the top door edge (Kelsey, pp. 176-77).

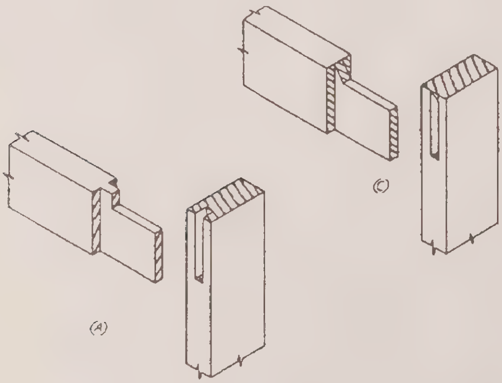
The joint formed by a haunched tenon (with a square haunchion) was called a "square haunched mortise and tenon" (Kelsey, p. 179) or "haunched mortise" (Frid, p. 96) – (with a bevelled haunchion) was called a "bevelled haunched mortise and tenon" (Kelsey, p. 179) or "mitered haunched mortise" (Frid, p. 96).

Mortise and Tenon Joint: A rectangular socket or mortise cut in one member, in which usually a finger or tenon from another member is glued, pinned or wedged (Scott, p. 226).

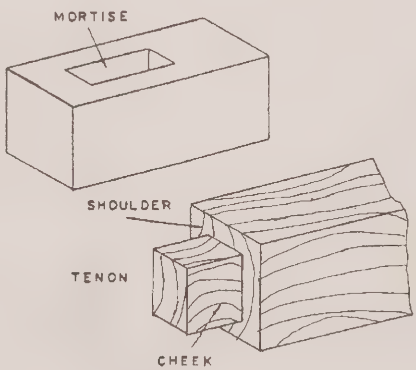
a. through or full mortise and tenon joint (Ramsey, p. 385) a joint in which the tenon is allowed to run through the mortised member for wedging (Kelsey, p. 178);

b. slip joint (Frid, p. 96) slip or open mortise and tenon joint (Ramsey, p. 385); slot mortise and tenon joint (Kelsey, p. 177); a joint in which the mortised member is open on three edges – not a true mortise and tenon joint (Scott, p. 238);

c. blind or stub mortise and tenon joint (Ramsey, p. 385) stopped joint (Kelsey, p. 178); a joint comprising a mortise which does not pass through a member into which is fitted a stub tenon (Scott, p. 38).



Haunched Tenon Joints. A-square haunched mortise and tenon, C-bevelled haunched mortise and tenon (Kelsey, p. 179)



Blind or Stub Mortise and Tenon Components (Hammond, p. 268)

Mullet: A piece of wood grooved to a certain width and slipped along the edge of a panel to ensure that it is the correct thickness (Scott, p. 228).

Muntin: A subsidiary vertical framing member in a door, framed into the rails, separating the panels, usually of the same width as the stiles (Scott, p. 229). This element is known variously as:

a. "mountings or more commonly muntings" (Hodgson, p. 258);

b. "centre stile" (Burrell, p. 165);

c. "meeting stiles" (Payne, p. 219); and

d. "middle stiles" (Gwilt, p. 656).

In the case of a four-panel door it was sometimes necessary to distinguish between the muntin above the lock rail and that below the lock rail, in which case the terms "top muntin" and "bottom muntin" were adopted (Talbot, p. 14).

Panel: An infilling of wood let into grooves or rebates in panelled framing, leaving the panel free to move relative to the frame (Scott, p. 242).

a. In the case of a six-panel door, the panels in descending order are "top panels," "middle panels" and "bottom panels" (Fleming, p. 79) or "frieze panels," "middle panels" and "bottom panels" (Gwilt, p. 656);

b. In the case of a four-panel door, the panels are "upper panels" and "lower panels" (Burrell, p. 165) or "top panels" and "bottom panels" (Hodgson, p. 255);

c. Panels placed with the longest dimension vertically or the grain running vertically, are called "standing panels" (Lowndes & Emerson, p. 59.41), "upright panels" (Hodgson, p. 258), "vertical panels" (*Canadian Woodworker*, p. 42);

d. Panels placed with the longest dimension horizontally or the grain running horizontally, are called "lying panels" (Lowndes & Emerson, p. 59.41), "laying panels" (Hodgson, p. 258), "horizontal panels" (*Canadian Woodworker*, p. 42).

Rail: A horizontal secondary member framed into vertical stiles (Scott, p. 276).

a. the uppermost rail, "top rail" (Hodgson, p. 258);

b. the next rail in descending (in the case of a six-panel door) "frieze rail" (Gwilt, p. 656);

c. the rail which carries the lock, "lock rail" (Burrell. P. 165), "middle rail" (Hodgson, p. 258); and

d. the lower-most rail, "bottom rail" (Lowndes & Emerson, p. 59.41), "kicking rail" (Scott, p. 276).

Relish: (possibly a North American term for a haunchion): a short projection on one side of a tenon, or between a pair of tenons which passes into the stile or rail to the bottom of the groove. This projection is called a "relish" and its purpose is to preserve some solid wood in the groove (International Textbook Co., p. 10.24).

Bottom Rail of Panelled Door (Talbot, p. 28)

Saw-horse: A four-legged stool made on the job by a carpenter for hand sawing (Scott, p. 298).

Stile (var. Style): The outside vertical members of doors (Hodgson, p. 257).

a. the one that hinges are affixed to is called the "hanging stile" (Hodgson, p. 258);

b. the one containing the lock the "striking stile" (Hodgson, p. 258), "shutting stile" (Fleming, p. 79), "lock stile" (Lowndes & Emerson, p. 59.41).

The stiles together were referred to as "outside stiles" (Gwilt, p. 656), "side stiles" (Payne, p. 219), "outer stiles" (Burrell, p. 165).

Trestle or Sawing-Stool: A rough bench for temporary service, particularly out of doors and remote from the workshop. A pair were often used by the joiner for holding quartering when cutting mortises, ripping with a hand-saw (Ward, Lock & Co., Ltd, pp. 193-95 and 219-20).

Wainscot or Dutch Oak: A species of oak grown in Germany and imported from Holland. It was employed in expensive fittings, because it was more beautiful than English oak. It was also softer and less liable to warp and split (Brees, p. 467).

A name frequently applied to the best kinds of oak boards because oak had been so much used for panelling (Chambers, p. 42).

3.0 MATERIALS

3.1 SELECTING A WOOD SPECIES FOR FRAMING

A great many wood species have been used in the past for door making. Writers frequently disagreed on the relative merits of a particular species. George O. Stevens & Co. of Baltimore, a sash, blind and door factory, advertised in their 1879 catalogue:

> Black Walnut, Ash, Cherry, Chestnut, Maple, Butternut and Mahogany [Front] Doors, both Solid and Veneered, furnished to Order...FRONT DOORS. OF BEST QUALITY WHITE PINE HAVING ON ONE SIDE HEAVY RAISED MOULDING AND CIRCULAR HEAD PANELS, AND ON THE OTHER SIDE FLUSH MOULDINGS AND SQUARE PANELS (Waite, pp. 6-7).

English writers consistently recommended "deal" for door framing:

> The doors of modern buildings are usually formed of deal and painted, although oak, wainscot, and even mahogany, are used in very superior dwellings (Brees, p. 145).
>
> A definition of "deal" which, depending on the period and local usage, came to mean a variety of things. Brees noted:
>
> DEAL, a fir board about 3 inches in thickness, and seldom exceeding 9 inches in breadth.
>
> Deals are imported from abroad, where they are cut into the proper thicknesses by machinery; those from Norway are the best for framing; Christiana are the most used for floors. The stuff is afterwards cut down in this country into boards of various thicknesses, to suit the purposes required, and is called according to the number of its subdivisions, as three-cut stuff, etc.; whole deal is $1^1/_2$ inches thick, and slit deal half that thickness.
>
> There are two kinds of deal in use – viz., yellow, and white. Yellow deals are the dearest, also the strongest, and therefore the most suitable for external work; the white is less liable to shrinkage, and is much used in joinery; as, panelling, etc.
>
> Deals are estimated by the hundred, which contains one hundred and twenty deals, reduced to a standard thickness of $1\text{-}^1/_2$ inches, and a length of 12 feet, notwithstanding whatever scantling they may actually be (Brees, p. 137).

Joseph Gwilt, another English writer concurred, but recognized that American wood was coming into general use:

> The wood principally used for joinery is of three sorts, pine, and white and yellow deal; the two first for panelling, and the last for framing. Of late years much American wood has been used, both for panels and frames. It works easily, is soft, free from knots, but more liable to warp than white deal (Gwilt, p. 654).

The *Encyclopedia of Carpentry and Contracting* presented a North American viewpoint:

> Common doors both internal and external, are made of "yellow pine" or Georgia pine throughout. A better class of interior doors have yellow pine frames and white pine panels. The latter wood should not be used for external work, as it is far too soft and will not stand wet. Superior Internal Doors are made throughout of Honduras mahogany, black walnut and oak; also of pine and baywood, veneered with Spanish mahogany. External Doors of oak, teak, walnut and pitch pine (Hodgson, p. 264).

Another volume in the same set concerned more with the fabrication of veneer doors, was not as confident about hardwoods:

> A white pine door is about the only door that can be made successfully from solid wood. In a house with, say, a dozen doors, what other wood is there that will absolutely hold its place during a reasonable period? Certainly yellow pine will not do it. A solid oak door is a pest, and should not be put in a house except under written instructions. Sycamore cannot be used solid, and certainly neither gum nor maple. Possibly walnut or butternut might, but who would think of using them under present conditions? (Hodgson, p. 35).

The *Quality Standards of the Architectural Woodwork Manufacturers Association of Canada* recommends an appropriate grade of the following soft woods for interior and exterior mill work: Douglas fir, Ponderosa pine, yellow cedar, hemlock and western red cedar. No specific hardwood species are named (Millwork, pp. 7-9).

The Canadian Standards Association standard for wood doors recommends that solid doors be made from western red cedar, yellow cedar, Douglas fir, western hemlock, western larch, Ponderosa pine, sugar pine, eastern white pine, western white pine, sitka spruce and California redwood (CSA, pp. 30-31).

3.2 SELECTING A WOOD SPECIES FOR PANELLING

White pine and deal were clearly the preferred woods for door panels (Brees, p. 137; Gwilt, p. 654; Hodgson, p. 264). Edward J. Burrell, writing in 1888 from London, had a slightly different opinion:

> The materials now generally used are mahogany, white wood, and other hard woods. These can be procured in fair widths and are almost as cheap as pine and infinitely better (Burrell, p. 167).

More recent authorities on the subject of door panels suggest pine (Macey, p. 237) or coniferous woods and poplar (Bailleul, p. 41).

3.3 SEASONING

Thoroughly seasoned lumber was chosen by the joiner for doormaking (Hodgson, p. 259).

> In joiners' work executed during the 13th, 14th and 15th centuries, the wood has neither warped, split, nor shrunk in the tenons and at the joints. This excellence is ascribed to the practice of seasoning the wood for at least six years after it was sawn, by first leaving it in damp places or even in water, and then stacking it in open piles under cover, when it was often turned and sometimes smoked; after such treatment the wood, when worked, has a tendency to acquire the appearance of Florentine bronze (Gwilt, p. 654).

4.0 SHOP PRACTICE

4.1 CONVERTING DEAL TO STOCK

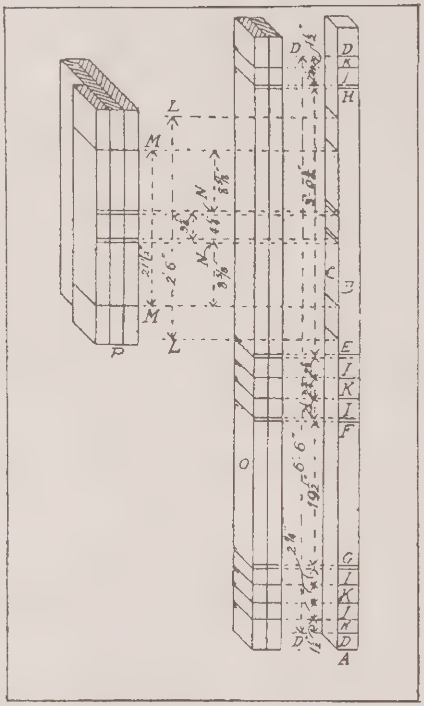
Deal was cut to length with a crosscut saw, to width with a rip saw and clamped down between hooks on the joiner's bench to be dressed down to thickness.

> From experience the joiner knew the thickness and the finish he would need for a particular piece. For a door frame he would reduce both faces and edges with the scrub plane and then with the jack plane to produce a working surface on each. The final silk smooth finish would not be worked up until the door was assembled. For the moment, a surface which would show gauge marks clearly for mortises, tenons and chamfers would suffice (LaFrance, p. 2).

Annotated photographs illustrating this part of the process can be seen in *Period Joinery, Halifax Citadel 1978* (Parks Canada, pp. 1-6).

4.2 SETTING OUT THE MEASURING ROD OR PLAN

When laying out a panelled door, a measuring rod or measuring plan was first prepared. A rod with the height measurements set out on one face and the width measurements set out on another face is described in the *Handbook of Doormaking, Windowmaking, and Staircasing.*



Setting Out a Four-panelled Door. (Talbot, p. 26)

A rod bisected on one face longitudinally with the height measurements set out on one side and the width measurements on the other is described in the International Correspondence Schools (ICS) Reference Library text Number 14.

A measuring plan is described and illustrated in the text *Cours de technologie professionnelle de spécialité du bois*. Unfortunately instructions on executing the vertical and horizontal sections required are not provided:

> This plan consists of two cross-sections:
>
> a) one **vertical section** representing the right-hand view,
> b) one **horizontal section** representing the bottom part of the door.
>
> Note: The measuring plan is not indispensable; marking out can easily be done with a simple technical drawing to scale (translated from Bailleul, p. 42).

4.3 SETTING OUT AND GAUGING THE FRAMING MEMBERS

If measuring rods are used, the rods are set on the stiles, the rails and then the muntins to transfer the marks. Mortise gauges are then used to locate the lines for the mortises.

> In the case of a measuring plan, the members are laid on the plan and the marks transferred (Talbot, pp. 27-29 and Bailleul, pp. 42-43).

4.4 CUTTING OUT THE FRAMING MEMBERS

When the measurements for the frame members were all set out and gauged, individual members were cut from the stock:

> The rails are cut to their full lengths including tenons, and the stiles are cut about 4 inches to 6 inches longer than is required (ICS Reference Library, p. 25).

The practice of cutting stiles longer than necessary is a very old tradition, which Kelsey explained:

> Door stiles are allowed to protrude beyond the top and bottom rails as lugs, to prevent door corners and edges from becoming damaged or picking up grit (which spoils tools) before hanging (Kelsey, p. 181).

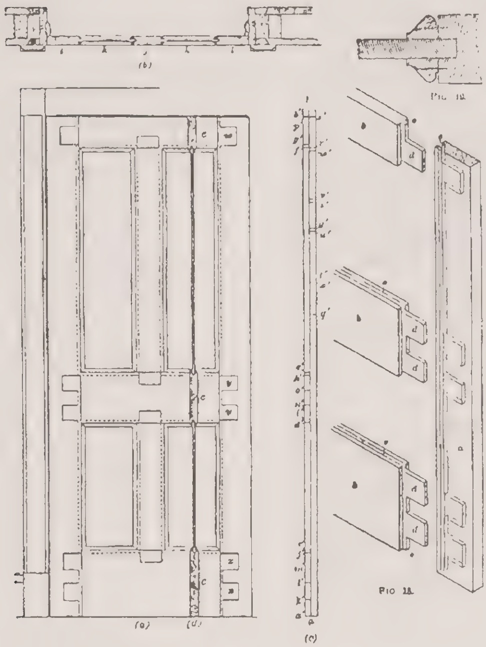
The *Handbook of Doormaking, Windowmaking and Staircasing*, on the subject of cutting off stuff for panel doors, states:

> … 3 ins. extra should be allowed in the length of the stiles, and $^1/_2$ in. in the rails — the latter to allow for cleaning off, and the former to prevent the wedges from splitting the haunchings (Talbot, p. 33).

4.5 MAKING THE MORTISES

Step by step, captioned photographs demonstrating the cutting of mortises are found in *Period Joinery, Halifax Citadel*, (Parks Canada, pp. 10, 11) and *Fine Woodworking Techniques* (Frid, pp. 96-101). A short description of the operation is provided by Gilles Lafrance:

> Once stock had been gotten up for stiles; i. e., thickness, width and length, each piece was then placed in a mortising bench where the joiner could hold it firmly while he bored holes with a brace and bit



Four-panelled Door Elevation (17a) measuring rod (17c) horizontal section (17b) vertical section (17d) perspective view of one of the stiles (18) [ICS, p. 10.22].

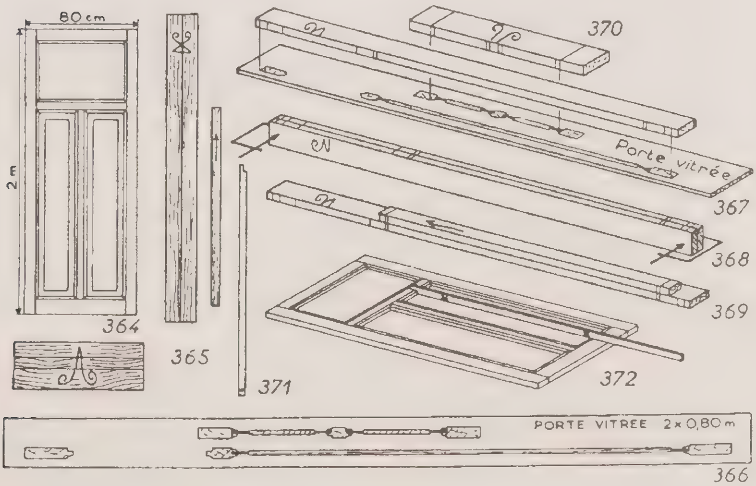


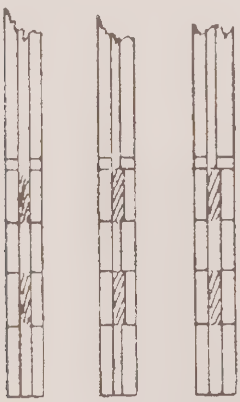
Illustration of a Measuring Plan (366) [Bailleul, p. 42]

> through the piece edgewise for each mortise and cleaned the mortise out with a firmer and mallet. This gave him a through mortise for each rail (LaFrance, p. 2).

Two methods were available for wedging up the "through" mortise and tenon joint: slitting the tenons at appropriate locations and driving wedges or alternatively driving wedges above and below the tenon. Both required dovetail shaped mortises. The ends of the mortises were splayed outwards after cutting (Kelsey, p. 179).

4.6 CUTTING THE TENONS AND PLOUGHING THE GROOVES

There is general agreement among joinery experts that following the making of the mortises, the tenons were to be cut, but not the shoulders (Talbot, p. 29; Hayward, p. 90). Annotated photographs illustrating the cutting of cheeks is found in *Period Joinery, Halifax Citadel*, (Parks Canada, p. 8) and *Fine Woodworking Techniques* (Frid, pp. 96-101). A variety of saws were used: frame saw, dovetail saw, back saw and ordinary rip saw.



Showing Various Widths of Grooves (Talbot)

After cutting the cheeks, the ploughing was done:

> The general rule is to use the same width of plough iron as mortise chisel, and this should always be done, providing that the panels to be used hold up to the requisite thickness to fill the grooves, and that there will be room for the moulding; if moulded doors are in hand.
>
> If, then, this rule is followed out, the edge of the stile when mortised and ploughed will be as A. ...If, however, thin panels are to be used, or extra room made for moulding, a smaller iron must be used for ploughing, so that the edge of the stile will be as B, and in this case the grooves between the mortises must be brought out to the width of the latter to make room for the haunchings, so that the appearance will be as C (Talbot, p. 30).

A plough or combination plane is used to cut continuous grooves in the "jointed edges" of the stile and rail members, where the panels are to be inserted. The operation of a plough is described in *The Amateur Carpenter and Builder*:

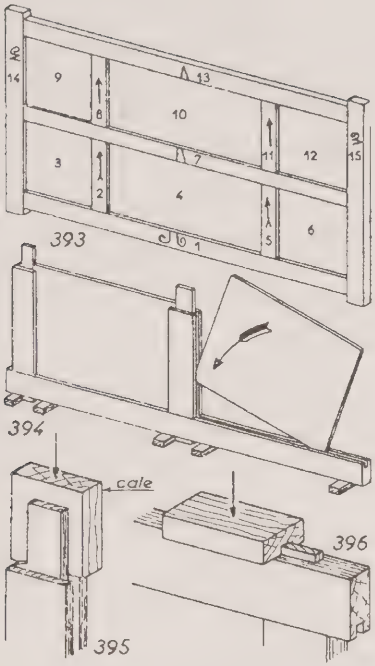
> The grooving [and where appropriate the rebating and moulding] done, the shoulders were next cut using a tenon saw, and cutting up to the mark but not on it. Following this the haunchings were cut out, as wedges to use later for wedging up the door when it was complete (Talbot, p. 30).

The mortises and tenons were cut and accurately fitted one at a time, and each marked for the place for which it was intended (ICS Reference Library, p. 10.25).

4.7 TRIAL ASSEMBLY

There are several reasons for making a trial assembly of the frame. It enables the joiner to take the measurements for the panel (LaFrance, p. 3). It permits verification of the work. If left assembled for a modest period of time, it allows for more seasoning:

> The door now having been made and the tenons carefully fitted to their respective mortises, the door is put together without glue or other fastening, and left until immediately before it is required to be fixed in the building, in order that it may have as long a time as possible to season (International Textbook Co, p. 10.25).



Fitting Together a Typical Section of Panelling (Bailleul, p. 47)

The process of assembling a typical section of panelling is described in *Cours de technologie professionnelle de spécialité du bois*. The references to panelling and finishes applied to a final assembly:

Assembly

The joints are fitted together in accordance with the proof marks and with certain precautions. Proceed as follows:

1. **Organize the work** in an orderly fashion to permit quick, efficient operations starting from the left…
2. **The panels must be fitted in place** with a slight rotating motion, the lower corner of the panel being fitted into the groove in the frame….
3. **Pound** on a large softwood block placed:

   a) **for ends, on the shoulder** of plain tenons…
   b) **for sides, flat against stiles**…

4. **Use a hammer** or mallet of the appropriate weight for the size of the work.

The following are to be avoided:

a) **Fitting and refitting in the improper order**, which would create play in the joints and waste time; joints should be fitted only once after making the necessary checks;
b) **Pounding the pieces without using a block**, which could mark them.

• • • •

Verification of Assembled Work

This applies to:

1. **Irregularities on flat surfaces**.
2. **Accuracy of angles**: this is checked with a square or diagonal measurement, bevel square or template.
3. **Uneven faces** of mortised elements.
4. **Straightness of long stiles** jointed with several rails.
5. **Overall dimensions**.

(Translated from Bailleul, pp. 46-47).

4.8 MARKING THE PANELS

A single reference to a technique for marking panels was discovered in *Cours de technologie professionnelle de spécialité du bois*:

Marking of panels

Once the joints in the door have been finished and, if necessary, fitted together (no trials that spoil the quality of the joints), the length and width of the panels are measured and marked on a panel measuring rod.

Description of measuring rod…. This is a small rod with a rebate equal to two groove depths cut away from one end.

Use of measuring rod…. The shoulder of the rebate is set against the inside edge of the door frame to measure the length and width of the panel. The finished panel dimensions are obtained by adding the length of the rebate to the measurements.

Note: Remember that a panel must be:

• exactly the right length in order to secure and square the door,

• slightly under the full width in order to allow the wood to expand in more humid surroundings.

(Translated from Bailleul, p. 48).

A ready-made panel gauge designed specifically for this operation was available to the joiner. One is illustrated in *Period Joinery, Halifax Citadel*, (Parks Canada, p. 7).

4.9 CUTTING OUT THE PANELS

On the subject of cutting panels from a single piece of stock, the *Handbook of Doormaking, Windowmaking and Staircasing* stated that panels should be:

> … cut off about 1-16th in. shorter than the space they have to fill (panel space plus depth of grooves), and also cut so much less in width, before anything else is done to them; they can then be faced up and planed to the right thickness to fit the grooves – first the ends, then the sides, or as it is called in technical language, "mulletted," and then the back planed off. If the door is to be left square, or only moulded one side, the panels are left as mulletted, …and, in position in the door, …but if to be moulded both sides, the bevel on the back of the panels must be planed off level… (Talbot, p. 31).

4.10 CLAMPING THE PANELS

Door panels, because of their width, were frequently made up of narrow boards. According to Gilles LaFrance, this type of work was frequently given to the apprentice:

> If a board wide enough could be had the panel was made of one piece with perfectly flat faces and bevelled edges all around. However, more often the panels were made up of narrow tongue and groove boards fitted up with a vee joint on both sides or with a quirked edge on each face to give a double line at each edge joint. While the solid one piece panel was the work of the joiner himself, for it let him demonstrate his skill in producing very smooth panelling, the tongue and groove panel being more tedious and requiring less skill was given to the apprentice to make. Making boarded panelling was considered good practice in the use of tools and the matching of materials (LaFrance, p. 3).

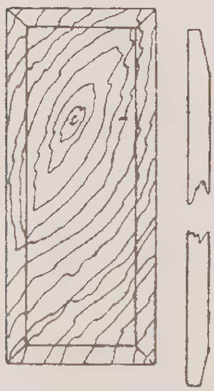


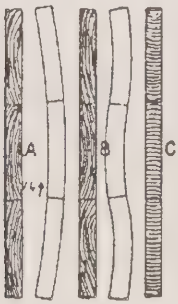
FIG. 38.—BACK OF PANEL, AND SECTION.

FIG. 39.—PANEL IN FRAMING, MOULDED ONE SIDE.

FIG. 40.—PANEL IN FRAMING, MOULDED BOTH SIDES.

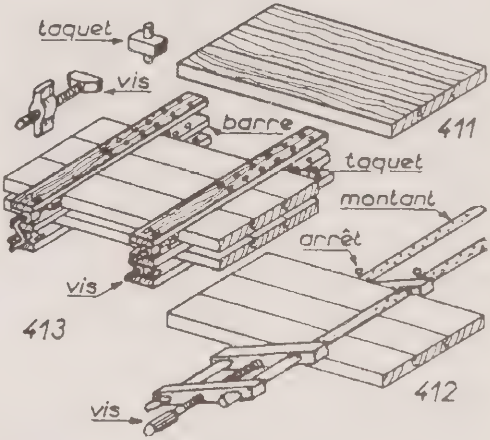
Several theories prevailed on how to select and arrange boards for a laminated design. A number of suggestions are found in *the Encyclopedia of Carpentry and Contracting*:

> When wide panels are used they will warp less if glued up in several pieces, as the pull of the fibres is lessened by the cutting, and the effect of the warping is diminished in the same ratio as their width. Much can be done to ensure the permanent flatness of panels by paying attention to the way the boards have been cut from the tree. The direction of the annual rings on the end will indicate this, and the various pieces should have their similar sides placed together. When a panel is glued up with the hollow or heart sides of the rings all on one face as at A, and the board warps, it will case in one continuous curve, as shown in the unshaded diagram, whilst if glued up with the heart sides reversed alternately, as shown at B, it will assume the serpentine shape shown in the unshaded diagram. Boards cut radically [*sic*, radially] or with the annual rings perpendicular to the surfaces, as at C, will swell less than the others, and will not warp perceptibly (Hodgson, p. 262).



Illustrating the Effect of Position on Parts of a Panel (Hodgson, p. 263)

Two techniques for clamping panels are discussed in *Cours de technologie professionnelle de spécialité du bois*, the panel bar press and the panel bed press.



Clamping Tools to Assemble Panels (Bailleul, p. 50)

4.11 FINAL ASSEMBLY

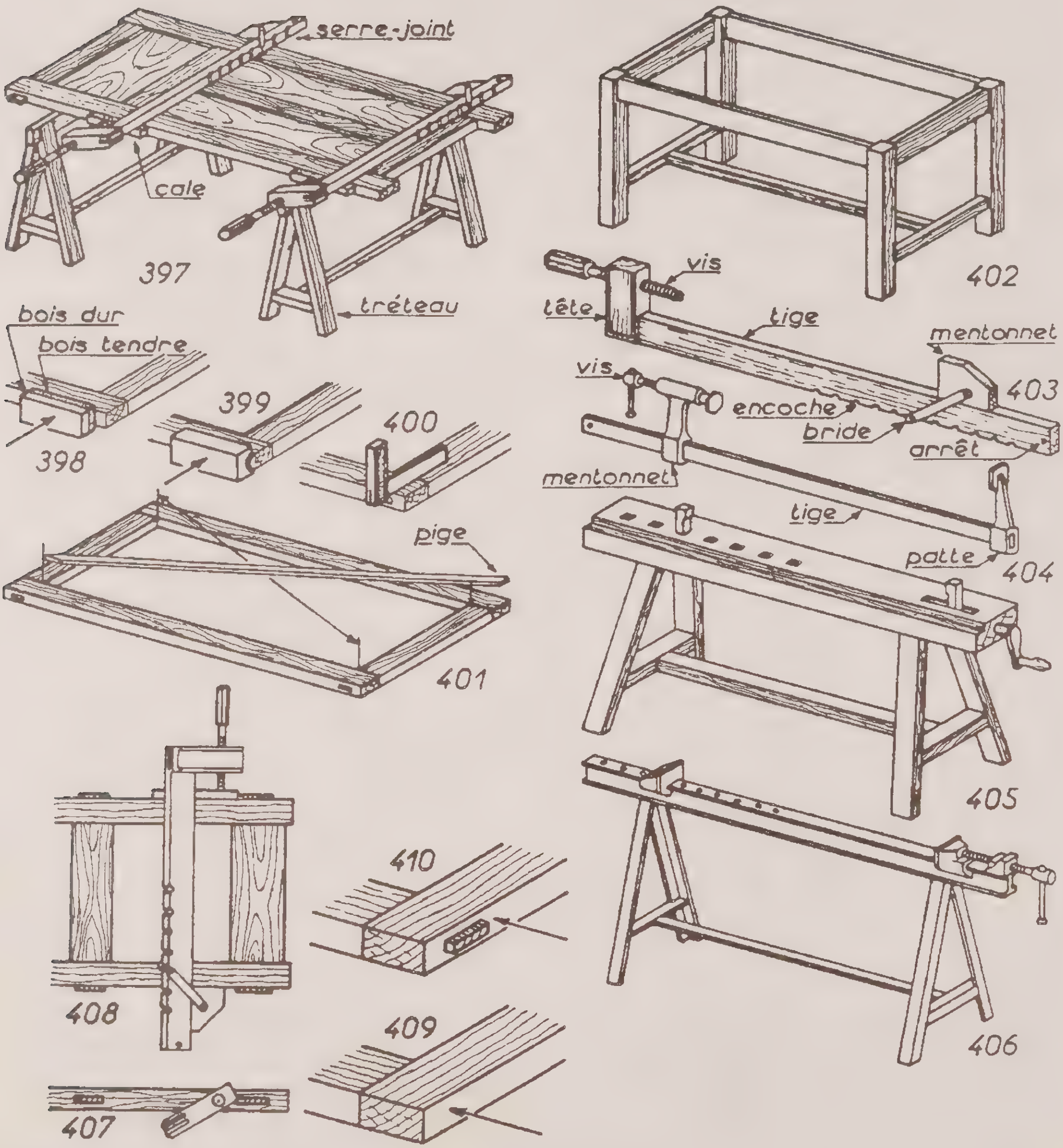
Final assembly was accomplished using a variety of tools and equipment. A simple procedure using trestles and bench clamps was described in the joinery section of the ICS Reference Library text:

> Before being glued, the door is taken apart, the mortises are cleaned, the tenons are spread with glue on their shoulder ends, and after the panels are inserted the whole is driven close with a heavy mallet, laid on a pair of trestles, and secured, until the glue is dry, by means of bench clamps, one of which is placed opposite each rail (ICS Reference Library, p. 10.25).

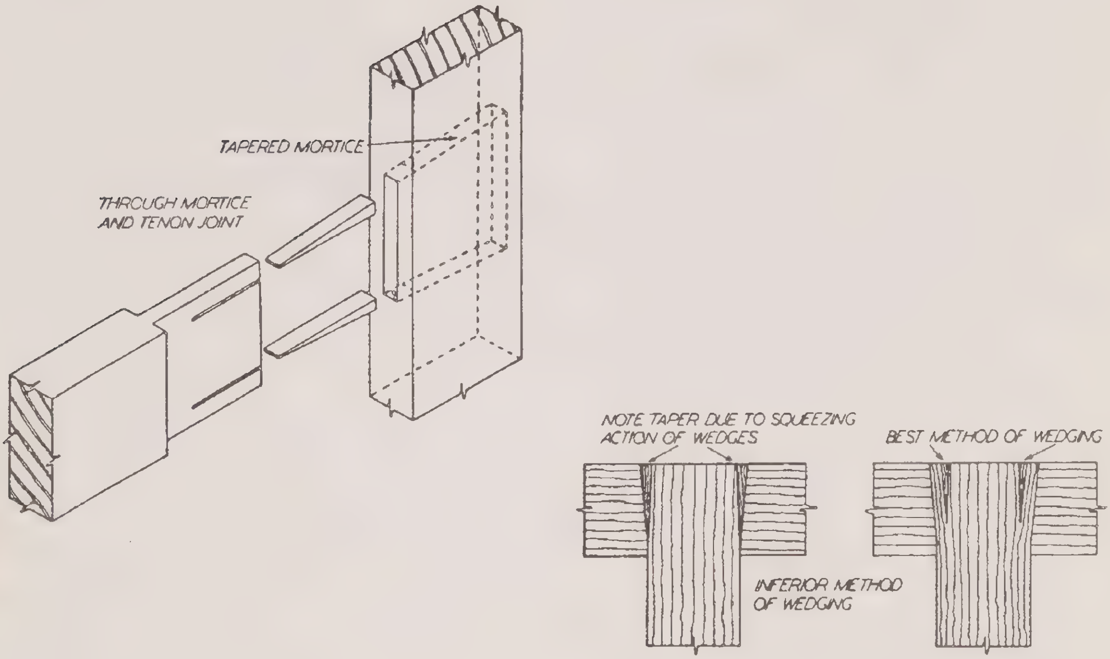
Gilles LaFrance in his article "Joinery" speaks of a piece of equipment, known as an erecting frame, which was used in assembling doors:

> An erecting frame, which was nothing but a large table without a top, was brought in and erected. The door would be assembled, squared up and finally locked into form on it, so it was a sturdy unit with true corners and stout legs (LaFrance, p. 3).

All aspects of clamping framework (tools and equipment, selection, use and storage; verification of clamped work applying pressure; etc.) are discussed at some length in *Cours de technologie professionnelle de spécialité du bois.*



Final Assembly Clamping Equipment (Bailleul, p. 48)



Wedging Through Tenons (Kelsey, p. 180)

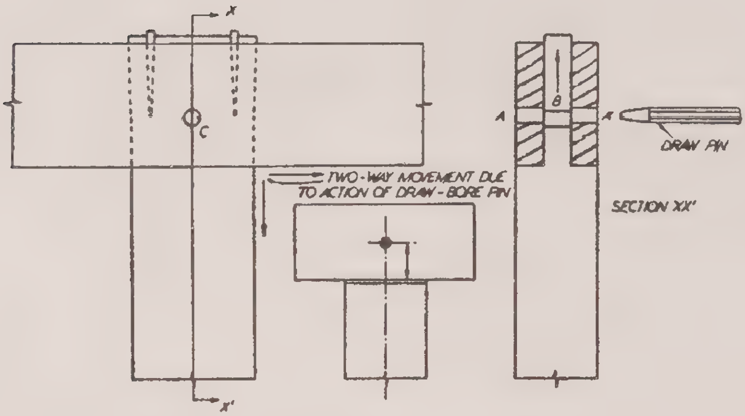
4.12 REINFORCING THE JOINTS

Generally two reinforcing techniques for mortise and tenon joints were used in door fabrication – pinning and wedging.

A brief outline of the two operations was provided by Kelsey in *Building Construction*:

> The ends of the mortices are splayed outwards by hand after machining, so that glued wedges can be driven in during assembly. Gluing all the joints before assembly and closing them with cramps gives strength and rigidity. Framing joints are sometimes reinforced by driving hardwood pins through holes bored in the door. This is more common in window frames and very large doors. The oak or beech pins pass through both tenon and mortice sides. The pins, tenon ends, and wedges are cut off level before cleaning up with plane or sander. The pins, because the grain is opposed to that of the stiles, may protrude objectionably after the door has finally dried out. Draw-bore pins can be used to close framed joints. The holes in tenon and stile are bored slightly out of line, causing the pin to force the tenon shoulders up to the stile edge.
>
> Although pinning theoretically strengthens the joint and is recommended for heavy doors and windows, it can actually prove disadvantageous. …If the wood between pin and joint line shrinks unduly, the glued joint may be broken through the immovability of the pin. Assuming careful application of adhesives to both mortices and tenons, pinning is of doubtful value (Kelsey, pp. 179-80).

A much more detailed examination of pinning and wedging is offered in *Cours de technologie professionnelle de spécialité du bois*.



Use of Draw-bore Pins. When the hole is bored as shown at C, it will draw the shoulders up and also force the inside edge of tenon up to the mortise side (Kelsey, p. 181)

4.13 FINAL FINISHING

The best description found of the final finishing steps for the completed door is provided by LaFrance:

> A small finishing plane would remove the steps at the shoulders of tenons and generally smooth the faces of rails and stiles. The try plane would dress off the ends of tenons and wedges and bring the door to its final overall dimensions (LaFrance, p. 4).

5.0 BIBLIOGRAPHY

Bailleul, E., and J. Heurtematte. 1973. *Cours de technologie professionnelle de spécialité du bois*. Librairie Delagrave, Paris. Quoted material and illustrations reprinted by permission: Librarie Delagrave, Paris Cedex 05.

Brees, S.C. 1853. *The Illustrated Glossary of Practical Architecture and Civil Engineering: Comprising the Theory and Modern Practice, with the Subjects of Office and Field Work*. L.A. Lewis, London.

Burrell, Edward J. 1901. *Elementary Building Construction and Drawing*. Longmans, Green and Co., London.

Canadian Standards Association. 1977. *Wood Doors, 0132.2-M1977*. Rexdale, ON.

Canadian Woodworker. 1908. "Planing and Molding, A Few Glass Door Designs," Vol. 1. No. 2 (April), p. 41.

Chambers, W. & R. 1872. *Chambers' Encyclopaedia*. Vol. 10. J.B. Lippincott, Philadelphia.

Fleming, John, Hugh Honour and Nikolaus Pevsner. 1972. *The Penguin Dictionary of Architecture*. 2nd edition. Penguin Books, Harmondsworth, Middlesex, UK.

Frid, Tage. 1978. "Mortise and Tenon, Choosing and Making this Basic Joint" in *Fine Woodworking Techniques*. Taunton Press, Newtown, CT.

Gwilt, Joseph. 1891. *An Encyclopedia of Architecture, Historical, Theoretical & Practical*. Revised edition. Longmans, Green, London.

Hammond, James J., et. al. 1961. *Woodworking Technology*. McKnight & McKnight, Bloomington, IL.

Hayward, Charles H. 1974. *The Complete Book of Woodwork*. Revised edition. Drake Publishers Inc., New York.

Hodgson, Fred T. ed. 1906. Carpentry and Joinery. *Encyclopedia of Carpentry and Contracting*. Vol. 2. Cree Publishing Company, Chicago.

__________., ed. 1906. Hardwood Finishing. *Encyclopedia of Carpentry and Contracting*. Vol. 8. Cree Publishing Company, Chicago.

ICS Reference Library. 1904. *Carpentry, Joinery, Stair Building, Geometrical Drawing, Architectural Drawing, Estimating and Calculating Quantities, Specifications*. No. 14. International Textbook Co., Scranton, PA.

Kelsey, W. Eric. 1974. *Building Construction*. David and Charles, Newton Abbot, Devon. Quoted material and illustrations reprinted by permission: David and Charles.

LaFrance, Gilles. 1978. "Joinery." Unpublished report, Restoration Services Division, Ottawa.

Lowndes, Wm. S., and David B. Emerson. 1926. *Architects' Blueprints and Specifications*. No. 448. International Textbook Company, Scranton, PA.

Millwork Contractors Association. 1972. *Quality Standards of the Architectural Woodwork Manufacturers Association of Canada*. Revised. AWMAC, Burnaby, BC.

Parks Canada. 1979. *Period Joinery, Halifax Citadel 1978*. Period Building Crafts Technical Study Guide. Parks Canada, Ottawa.

Payne, A.H. 1860. *The Builder's Practical Director*. A.H. Payne, Leipzip, GER.

Ramsey, Charles George, and Harold Reeve Sleeper. 1956. *Architectural Graphic Standards*. 5th edition. John Wiley & Sons, New York.

Scott, John S. 1974. *A Dictionary of Building*. 2nd edition. Penguin Books, Hammondsworth, Middlesex.

Talbot, Antony., ed. 1980. *Handbook of Doormaking, Windowmaking, and Staircasing*. Sterling Publishing Company, New York. Quoted material reprinted by permission: Sterling Publishing Co., Inc.

Waite, Diana S., ed. 1972. *Architectural Elements, the Technological Revolution*. Pyne Press, Princeton, NJ. Reprint of George O. Stevens & Co., *Builders Supplies Catalog*. 1879.

Ward, Lock & Co., Ltd. ca. 1880. *The Amateur Carpenter and Builder*. London.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

8.2

PERIOD JOINERY

WINDOW MAKING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

This article aims to bring together the references on window making, so that they may be read sequentially from the initial selection of timber to the finishing of a completed window sash.

For the sake of simplicity, only those references on a six-light casement sash, with mortise and tenon joints have been chosen.

Unlike door making described in Section 8.1, window making was a complex joinery activity:

> … sash work can involve elaborate moulding and jointing and it is therefore not surprising that a number of specialist tools were evolved by men who, in a year's work, might stick (i.e. plane) several miles of moulding and cut thousands of joints (Arnold and Walker, p. 2).

A comment in an Arnold and Walker catalogue concerning window-making tools explains some of the problems faced when writing on window making:

> It is a curious fact that none of the 17/18th century writers on carpentry and joinery go into detail on window sash construction even though, like Roubo, they may be meticulous about everything else right up to the window frame itself. Perhaps the subject has always been a little mysterious to the non-specialist and it is therefore only to be expected that many of the puzzles that crop up regarding woodworking tools turn out to be related to sash work (Arnold and Walker, p. 2).

This article does not attempt to cover joinery practice in the millwork mill or factory which took over much of the sash production in the latter half of the 19th century.

The techniques of building a custom, hand-crafted window sash have been all but forgotten. Were it not for a resurgent interest in hand-tool work, a growing number of antique tool collectors and a proliferation of articles on woodworking tools, the process would be all but impossible to reconstruct. Although writers such as W.L. Goodman in England and Henry C. Mercer in the United States have spent a lifetime researching woodworking tools, they readily admit to being stumped on a number of tools and processes.

> The late Edward Pinto had one [Dowelling Box & Collar] in his Museum of Wooden Bygones at Northwood about twenty years ago and I was as mystified about it as he was. It was obviously some kind of drilling jig, but neither of us could imagine what purpose it might have served. It has now been identified from Peter Nicholson's 'New Director' of 1834, showing how sash bars were dowelled to strengthen the joints between them. This was dealt with in some detail in the Arnold and Walker Catalogue No. 6. Like the side-working planes,…this is another example of a tool and process which must have been perfectly familiar to the craftsmen concerned at the time, but which had been completely forgotten a few generations later (Goodman, p. 55).

The tools and processes described in this paper are a reflection of joinery practice in the 18th and early 19th centuries. Beginning about 1850, dramatic changes in window sash construction occurred. One of the first changes was in the design of the sash itself. The number of lights, and consequently the number of sash bars, was drastically reduced:

> With regard to sash-windows, it is unlikely that the amateur will ever attempt to make a window, having the sash divided into many and small compartments as was usual in the latter part of the last and the early part of the present century, until the duty on glass was taken off – and glass being consequently much cheaper, the fracture of a pane is not a matter of so much moment as it was years ago. Indeed, except in fancy work for green houses and conservatories, sash mouldings are now but seldom used. In most cases the sash at top and bottom consists of a frame in which one large pane is set, or at the utmost the space is divided into two parts by one vertical bar, or into four parts by a vertical bar and a horizontal bar crossing each other at right angles (Ward, Lock & Co., Ltd., p. 131).
>
> • • • •
>
> More significant than the reduction in the number of sash bars, was a shift in the last quarter of the 19th century to mill-run mouldings and pre-finished wood products, i.e., window sash. The resulting decrease in handwork eliminated the need for many specialty planes and other tools (Sellens, p. 8).

The only source used which came even close to describing the series of steps followed in making a six light, through mortise and tenon joined, casement sash was the *Handbook of Doormaking, Windowmaking, and Staircasing*. It is a republication of joiner's handbooks dating from the era just before widespread use of power tools.

Instructional texts such as No. 14: *Carpentry, Joinery...* by the International Correspondence Schools (ICS) Reference Library, and *Encyclopedia of Carpentry and Contracting, Carpentry and Joinery, Volume 2*, usually helpful on joinery questions, were weak on window making.

The *Chronicle of the Early American Industries Association*, and *Fine Woodworking* yielded a number of valuable articles, particularly on working the bars and sash stuff (sash stock).

Woodworking tool histories by H.C. Mercer and W.L. Goodman provided information on individual hand tools. A recently published sales catalogue from Arnold and Walker, featuring window making tools, contained a surprising amount of original information.

A dictionary of tools, period tool catalogues, a privately printed book on woodworking planes and a guide to elementary carpentry and joinery round out the sources used.

2.0 DEFINITIONS

Many of the following terms and definitions are taken from period sources and may describe a range of meanings dependent upon locale and date. The various terms and definitions are not always conclusive, especially when reading period references to window making.

Casement Sash: those in which the sashes which open are hinged, either at the sides or at the top, opening either outward or inward (Talbot, p. 95). They are known variously as:

a) French Sashes
The sashes of a window are sometimes hung on hinges like folding doors, one on each side, meeting in the centre, and overlapping each other. They are fastened by long vertical rods or laths (Brees, p. 359).

b) Fillister (Scotland and USA: Filletster)
A general term for rebating planes that are fitted with fences (Salaman, p. 327).

c) Firmer Chisel (or Forming Chisel)
A general term for the ordinary chisel of fairly sturdy build. It has a parallel blade with a square cutting edge, from 2 mm to 76 mm wide. It is normally made with a tang fitted to a wooden handle by a ferrule. It is used for joiner's work, and is strong enough to be driven by a mallet (Salaman, p. 139).

Firmer Chisels (Mercer, p. 164)

Franking: different descriptions of "franking" are found. Burrell illustrated a horizontal sash bar tenoned into a continuous vertical sash bar and stated:

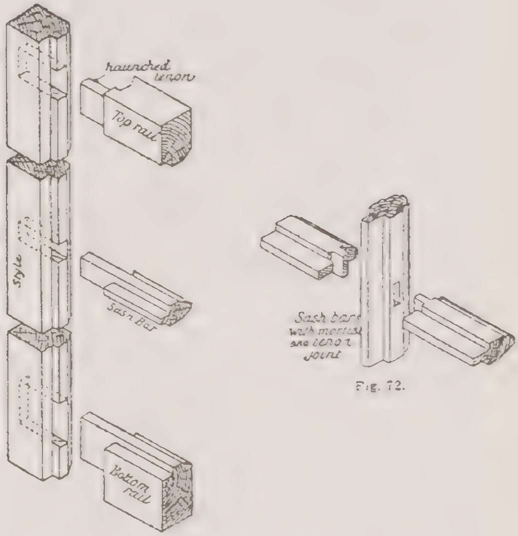
> In the lower figure a part of the tenon is haunched out: this does not require so large a mortise in the other bar, and is known as "franking" (Burrell, p. 190).

Fred T. Hodgson illustrated a similar situation but stated:

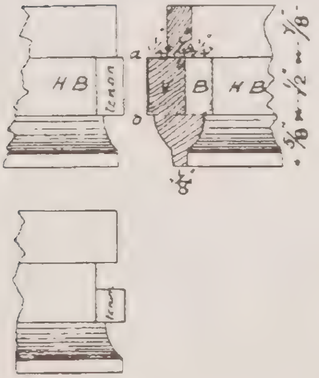
> An alternative to halving in sash bars is to arrange that the bar which is subjected to the greater stress – as for example, the vertical bars in sliding sashes, and the horizontal bars in hinged casement sashes – shall be continuous; this continuous bar is mortised to receive the other, which is scribed i.e., cut to fit the first, and on which the short tenons are left. This method is called "Franking the Sash Bars" (Hodgson, pp. 203-4).

An illustration by W. Eric Kelsey included what he described as a franked tenon and a franked and halved tenon (Kelsey, p. 216).

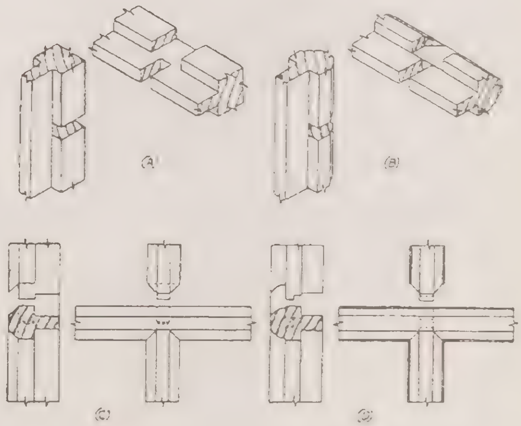
Mortising Chisels (Mercer, p. 168)



Details of Joints in Sashes (after Hodgson, p. 204)



Cross section of Upright Bar (VB) Two Horizontal Cross Bars (HB) (after Burrell, p. 190)



Methods of Jointing Sash Bars (a) halving plain and square bars, (b) halving chamfered bars, (c) franked tenons with scribed bevelled bars, and (d) franked and halved tenons with ovolo-moulded bars (after Kelsey, p. 216)

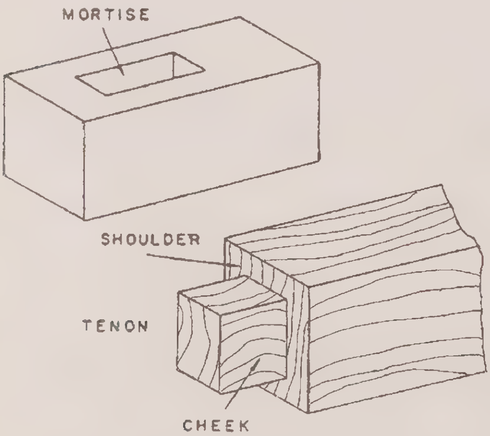
Haunched Tenon: a tenon which is narrower at the tip than at the root. The wider part is called the "haunch" or "hauncheon" (Scott, p. 172); "haunchion" (Kelsey, p. 176); and haunching (Talbot, p. 25).

Haunchions may be bevelled or square and allow a mortise to be kept back from the top door edge (Kelsey, pp. 176-77).

The joint formed by a haunched tenon (with a square haunchion) was called a "square haunched mortise and tenon" (Kelsey, p. 179) or "haunched mortise" (Frid, p. 96); with a bevelled haunchion it was called a "bevelled haunched mortise and tenon" (Kelsey, p. 179) or "mitered haunched mortise" (Frid, p. 96).

Marking Gauge: a beechwood bar with a steel point projecting at right angles from it near one end and a hardwood block sliding along it which can be locked at any point along the bar. It is used for marking lines parallel to the face of the wood which the block travels along (Scott, p. 217).

Mortise and Tenon Joint: a rectangular socket or mortise cut in one member, in which usually a finger or tenon from another member is glued, pinned or wedged (Scott, p. 226; Hammond, p. 252).

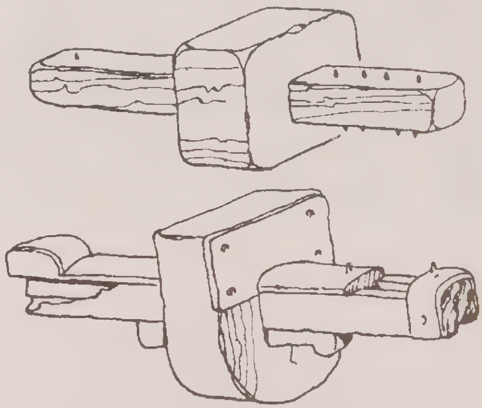


Mortise and Tenon Components

Through or full mortise and tenon joint (Ramsey, p. 385) a joint in which the tenon is allowed to run through the mortised member for wedging (Kelsey, p. 178).

Slip joint (Frid, p. 96) slip or open mortise and tenon joint (Ramsey, p. 385); slot mortise and tenon joint (Kelsey, p. 177); a joint in which the mortised member is open on three edges – not a true mortise and tenon joint (Scott, p. 238); blind or stub mortise and tenon joint (Ramsey, p. 385); stopped joint (Kelsey, p. 178); a joint comprising a mortise which does not pass through a member, into which is fitted a stub tenon (Scott, p. 38).

Mortise (Mortice) Gauge: the mortise gauge is similar in general principle to the marking gauge. However, it has in addition a slide working in a groove in the bottom side of the bar, by which means two lines parallel to each other and to the edge of the wood can be marked at one operation, the steel point in the groove and the head of the gauge being set at the required distances from the fixed steel point (Ward, Lock & Co., Ltd., p. 112).



Mortise Gauges (after Salaman, p. 204)

A marking gauge with two spurs instead of one was used for marking the double parallel lines showing the position of a tenon or mortise or similar joint, thus avoiding the need to scribe two lines separately.

Mortising Chisel: a general term for various chisels used for mortising. All have an extra strong blade, a stout handle to take the mallet blows. The blades are thicker back-to-front than other chisels in order to resist bending when levering out the waste in a deep mortise.

The joiner's mortise chisel has a blade 6 mm to 25 mm wide, with an oval bolster and a stout oval handle (Salaman, p. 141).

Muntin: see sash bar

Rail: a horizontal secondary member with tenon cut on it, framed into vertical stiles (Scott, p. 276).

a. the upper-most rail, "top rail" (Hodgson, p. 201; Brees, p. 360).

b. In double-hung window: the bottom rail of the top sash and the top rail of the bottom sash are called "meeting rails" (Burrell, p. 188). The rails of sash windows which touch when the window is closed are called "meeting rails or check rails" (Scott, p. 275).

c. the lower-most rail is called the "bottom rail" (Hodgson, p. 201; Brees, p. 360).

Rebate: (Britain) – a long step-shaped rectangular recess cut in the edge of a timber (Scott, p. 275). In other places, "rebate" is known variously as:

a. rabbet (USA) – a rectangular or square channeled groove or recess cut from the edge of a previously planed or otherwise finished piece of wood, called stuff (Roberts, p. 22); and

b. check (Scotland) – see rebate above (Scott, p. 275).

Glazing rebate: the recess cut in sash or bar stuff specifically for holding the glass.

Rebate Plane (Rabbet plane, boxing plane, check plane): ordinary (or common) rebate planes are made of wood or metal and are flat across the sole in which the cutting iron extends to the extreme edge on one or both sides (Salaman, p. 348).

Sash: defined variously as follows:

a. Britain – sliding glazed frames running in vertical grooves (Fleming, p. 251). A sliding light of a double hung sash window (Scott, p. 296).

b. Scotland – any light of a casement or sash window (Scott, p. 296); (in this example the term "light" refers to the entire frame unlike the more popular North American usage for each pane of glass).

c. USA – lighter frames for holding the glass of a fixed or movable window (Hodgson, p. 201).

Sash Bar: any intermediate members, whether vertical or horizontal, are named "bars" (Hodgson, p. 201; Burrell, p. 189; Brees, p. 34).

Historically the usage of the term "sash" bars differentiated between a wooden window and a leaded framed, or more commonly, between a sliding frame and a hinged frame. Except when quoting period usage, the popular North American usage will be used – that is, without distinguishing material or method of operation.

a. Astragal: Scottish for glazing bar (Scott, p. 25; International Textbook Co., p. 10.41);

b. Glazing Bar**:** a rebated wood bar which holds the panes of glass in a window. The term "glazing bar" is often used for roof lights or for patent glazing (Scott, p. 161); and

c. Upright Bar: to distinguish vertical bar members. (Talbot, p. 106). "Cross bar" to distinguish horizontal bar members (Talbot, p. 106); also known as "window bar," or more commonly "muntin" (Harris, p. 324).

Sash Dowelling Box: a specialized window maker's tool used for holding sash bars while a hole was bored in the end grain for dowelling. A variety of clamping mechanisms for grasping the bar, as well as guide block arrangements for guiding the bit.

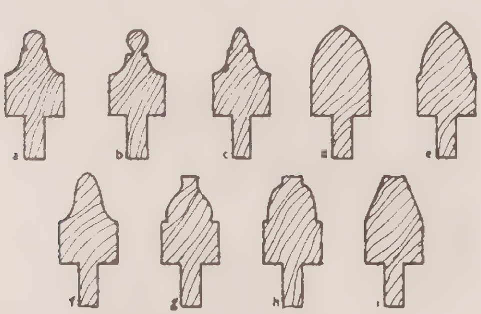
Two Sash Dowelling Boxes (after Arnold and Walker)

Sash Fillister (Back fillister): when working sash timbers, the rebates may be cut on either the left-hand or right-hand side of the wood. The ordinary moving fillister can be used for the left (near) side. For the far side, a plane is used similar

to the moving fillister except that the cutter, stop and spur are mounted on the left-hand side of the stock, instead of the right. Thus the fence bears on the face of the work and instead of being fixed to the sole, is carried on two stems like the plough plane. The cutting iron is single, skewed, shouldered, bedded at about 50° and extends all the way across the sole (Salaman, p. 327).

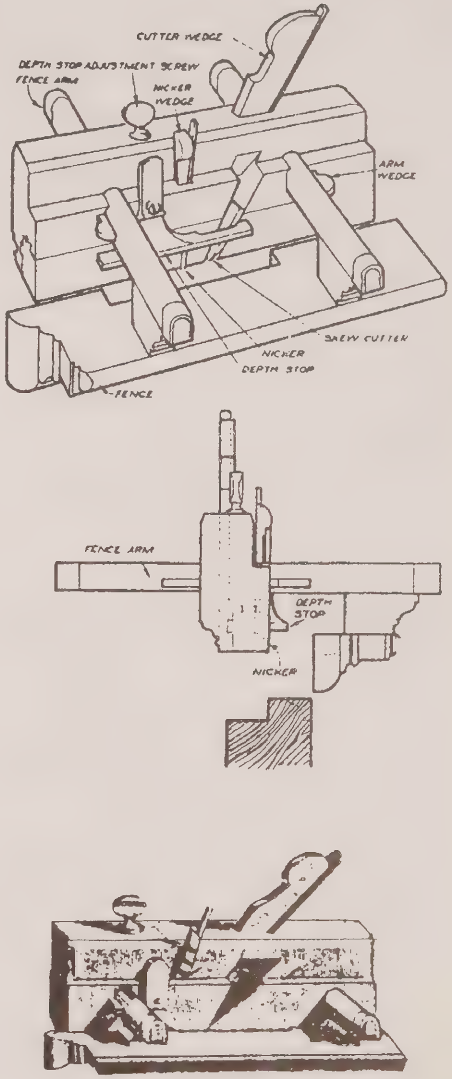
A number of stem or arm arrangements were available. The wedged stem and screw stem were the most common. The principal technical problem in designing sash fillisters was in getting rid of the shavings. In 1812 Peter Nicholson classified sash fillisters in two groups according to whether they threw the shavings onto the bench or off it. With the first type the shavings piled up; with the second they had to climb over the depth-stop and fence before falling to the floor. The second type seems to have become the more popular during the 19th century (Arnold and Walker, p. 6).

Sash-Moulding Plane: the sash-moulding plane was used for sticking (planing) the moulding down the face of the sash and bar stuff (Goodman, p. 55).



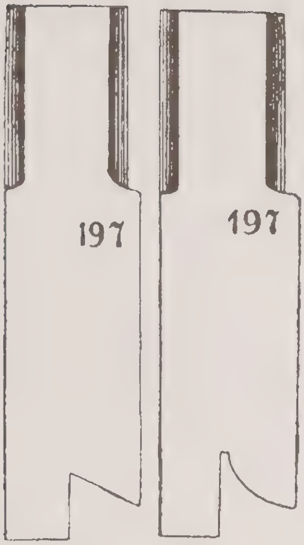
Sash – Moulding Profiles (a) Astragal and Hollow (b) Astragal and Quick Hollow (c) Astragal and Scotia (d) Gothic (e) Gothic and Fillet (f) Lamb's Tongue (g) Ogee Sash (h) Ovolo (i) Rustic (after Salaman)

The size of the plane depended on the thickness of the sashes and the width of the glazing bars which varied from about 13 mm to 25 mm ($^1/_2$ – 1") (Salaman, p. 354). The planes were manufactured in pairs. There has been much speculation on the reasons for this. Goodman thought that it stemmed from the manufacture of the astragal and hollow profile which required special working to produce bars which stood back from the face of the sash stuff (Goodman, pp. 54-55). Salaman suggested the No. 1 was for removing the main bulk of the waste, and the No. 2 for planing down a shade further and giving the finishing cut to the profile (Salaman, p. 354).

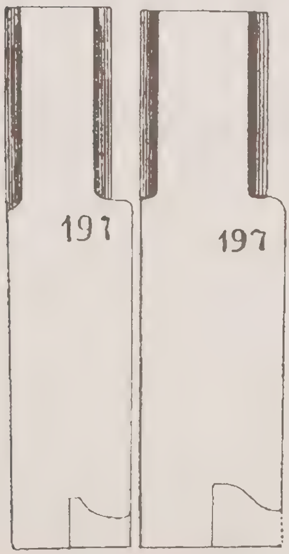


Wedged Stem Sash Fillister (after Salaman)

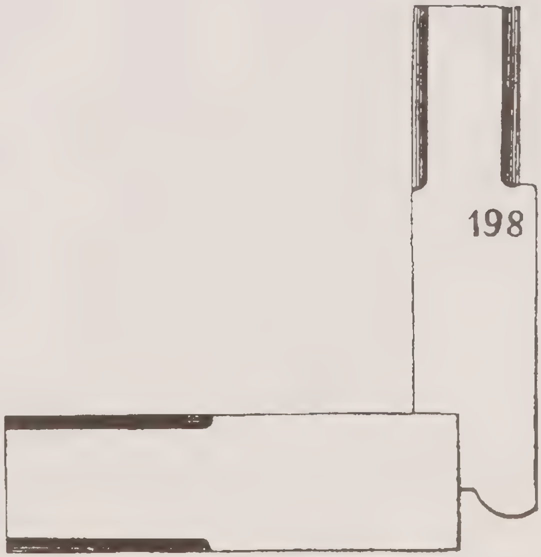
Sash Plane (Stick-and-rebate plane): the sash plane was a specialized tool used in making windows. It was in fact a



No. 197—Bevil. No. 197—Gothic



No. 197—Ovalo No. 197—O G.



No. 198—Double Ovalo.

Sash Scribing Planes: (a) Gothic, (b) Bevil, (c) Ovolo, (d) Ogee, and (e) Double Ovolo (after Baldwin Tool)

combination of a rebate and a moulding plane, fashioned so that both cuts could be made at the same time. One side cut the rebate for the glass while the other side cut the decorative inside moulding. The ovolo and bevel patterns were the most frequently stocked planes.

Examples of sash planes are found with a single plane body and either one or two irons, or the more common double sash plane (two plane bodies joined by arms). The latter type had two irons. Similar to sash fillisters, wedged arms and screw arms were used.

By adjusting the two planes the tool could be adapted to different bar widths.

The sash plane was rarely used in Europe, but widely used in North America.

Sash Scribing Plane (Sash Coping Plane): a special moulding plane with a reverse or counter profile corresponding to simpler sash mouldings and used for scribing the shoulders of sash bars in order to fit one moulded profile over the other (Salaman, p. 355). Illustrated above.

They were also used to undercut the bottom and top rails of a window sash so that they would join snugly with the moulded side stiles (Sellens, p.71). The planes were sold to match each pattern of sash plane because the coping cut must be the reverse of the moulding cut made by the sash plane.

The planes were available as singles or doubles. The latter automatically controlled depth.

Sash Stuff (Sash Stock): wood which has been cut to stock sizes and shapes and prepared for making window frames (Harris, p. 424).

Sash Templet: these hardwood templets are used as a guide for cutting the mitre and "scribing" the moulding on glazing bars etc., i.e. the fitting of one moulded profile over another.

a. Saddle or double sash templet – this is a piece of hardwood (usually beech), 185 mm (7 $^1/_2$ in) long and about 38 mm ($1^1/_2$ in) square, with a groove shaped to a reverse of the sash moulding and designed to be laid over a sash bar.

   There are two types, but they could be combined in the one tool. In the first type the end of the templet is cut square and shaped to the counter-profile of the moulding. This was probably used with the sash scribing plane.

   The second type, or the other end of the combined tool, is mitred on each side. It was laid over the sash bar and the projecting part of the moulding pared down flush with the mitre on the templet on each side. This gave an exact marking of the amount of material to be removed with the sash gouge or with the coping saw. This method eventually superseded the use of the scribing or coping plane.

b. Side or single sash templet – this is the corresponding tool to (a) but designed for marking the scribed moulding on door or sash rails. It consists of one-half of the grooved templet, with the appropriate counter-profile worked on one side. In the modern type both ends are cut at 45° to give the right-hand and left-hand mitres in the one tool, the material being then removed with the appropriate sash gouge (Salaman, pp. 482-83).

Scribe: to shape one member to the surface which it touches, thus to fit a board snugly to a surface which is not straight.

Scribing gouge (sash gouge, coping gouge): light in-channel gouges made in sets of six or nine sizes from 3 mm to 25 mm (1/8 to 1 in.) Used for scribing sash or door stuff (Salaman, p. 214).

B C.S. Scribing Gouge, Boxwood Carving Pattern Handled.

Scribing Gouge (after Salaman)

A variety of gouges were made with a handle which extended along the back of the blade to stop the gouge at the right point when it was being pushed through the fibres (Arnold and Walker, p. 18).

Setting out: the preparing of dimensioned rods (setting-out rods) for some joinery task.

Setting-out rod (height/width rod, measuring rod): dimensioned rod used in joinery on which is marked certain key dimensions (Scott, p. 307). For a window sash such dimensions as overall height and width, stile, rail and rod widths, lengths of mortises, depths of rebates and mouldings, etc., are set out on the rod.

Spring angle: sash moulding planes were generally tilted or sprung at a set angle ("spring angle") when sticking a mould-

ing. The angle was determined by the manufacturer and usually ranged from 30° to 45°.

Many explanations for the spring angle are offered: to remove all the nearly vertical parts, as far towards the horizontal position as circumstances will admit – the most favourable position to maintain the form of the cutter when sharpening it (Holtzapffel, pp. 492-93). A sprung plane gives greater control because the guide fence is pressed against the stock – its geometry will also allow its mouth to be more uniform in width (Vandal, pp. 73-74).

Standing fillister (halving plane): a rebate plane with an integral fixed fence and depth stop, called a standing fillister or halving plane, was sold by plane manufacturers in the early 19th century but apparently fell out of fashion. The advantage of the tool for making a specific sized rebate was that the shape of the tool provided both a guide and a stop without need for measurements or adjustments (Sellens, p. 103). It was particularly suited to cutting long runs of rebated stock of fixed width and depth, e.g. for sash or greenhouse work with no moulding (Salaman, p. 327).

Sticking: moulding planes produce mouldings on the edges of frame members called sticks, hence the process is called sticking (Vandal, p. 72).

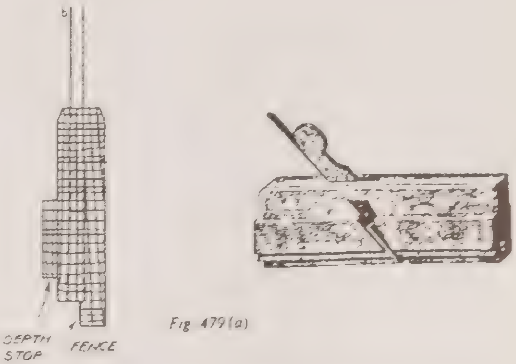
"On and down." With the plane perpendicular to the moulding and the fence against the edge of the prepared wood – the "on" is the distance the plane can proceed upon the wood. The distance the plane can descend vertically until the depth stop is reached is called the "down" (Holtzapffel, p. 493).

Sticking board: a framed board in which small pieces are held steady while they are being moulded with a plane (or stuck) [Scott, p. 337].

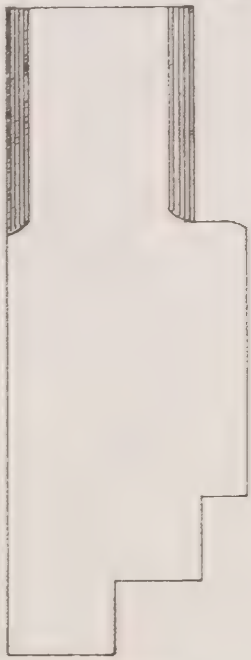
Sticking boards took various forms. Examples are found in the *Handbook of Doormaking, Windowmaking, and Staircasing*, "Gabriel & Sons, Stock Inventories," W.L. Goodman and the *Dictionary of Tools*. A description of the work done in a sticking board is given in the latter source.

> A board used flat on the bench with an arrangement of pins and grooves for holding the wood when working the rebates and mouldings on sash bars. The wood is held in place with either a screw head or by points of nails which are driven in under the board so that their points project above. The rebates are worked in succession on each side; the resulting fillet is then inserted in the horizontal groove in the side of the board.

and the moulding stuck on the face edges. Another type, for sticking beads, consists of a plain board with a groove in which the material is held vertically while the bead is stuck on the edge (Salaman, p. 480).

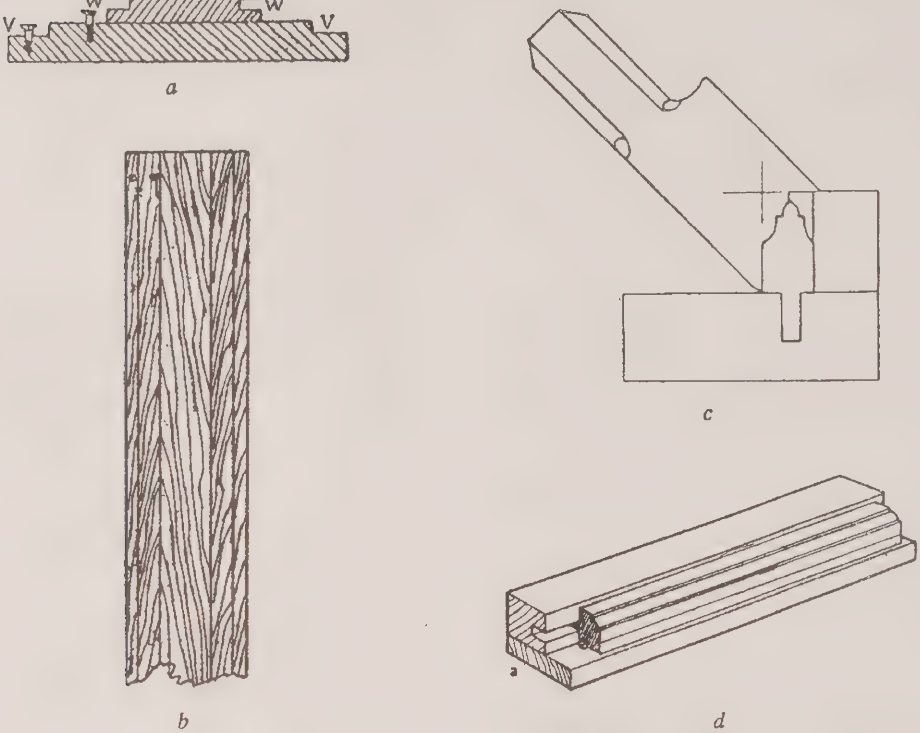


Standing Fillister or Halving Plane (after Salaman and Sellens)



No. 4D1 Halving Plane

Standing Fillister or Halving Plane (after Salaman and Sellens)



(a) Section of a Sticking Board (after Talbot); (b) Plan View (after Talbot);
(c) Sticking Board for 12mm Astragal & Hollow Sash (after Goodman); and (d) Isometric View (after Salaman)

Stile: an upright end-framing member mortised to enclose a tenon of a rail (Scott, p. 337; Brees, p. 414). A variation defined by Hodgson: "Styles" are the outer uprights of sashes (Hodgson, p. 201).

Stubbing In: the inserting of a tenon into a blind or stub mortise. The joint comprising a mortise which does not pass through a member into which a stub tenon is fitted (Scott, p. 38).

Trestle or sawing-stool: a rough bench for temporary service, particularly out of doors and remote from the workshop. A pair were often used by the joiner for holding quartering when cutting mortises, ripping with a hand-saw (Ward, Lock & Co., Ltd., pp. 193-95, 219-20).

3.0 MATERIALS

3.1 SELECTING A WOOD TYPE FOR SASH MEMBERS

Few writers about wood windows bring up the subject of selecting a wood type for sash members. An exception is G. Lister Sutcliffe, a British architect, who noted in *The Principles and Practice of Modern House-Construction:*

> Red (yellow) deal is the wood most frequently used for the sashes themselves and the other parts of the frames, but in high-class buildings oak, mahogany and other woods are preferred (Sutcliffe, p. 1.159).

His recommendation was echoed by another British architect, Frank W. Macey in 1922. He indicated that deal should be specified for sash in "all ordinary positions in any ordinary building." For sash in windows with panelled elbows, soffit or window backs he suggested deal (oak, walnut or mahogany) [Macey, pp. 191-96].

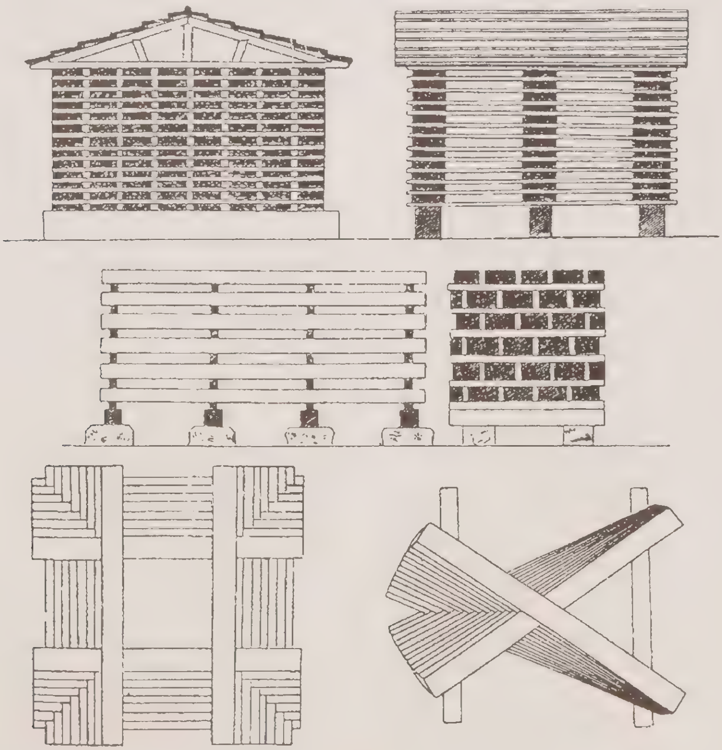
North American writers on wood types suggested clear white pine (Holland and Parker, p. 131) and white-pine, factory (International Textbook Co., p. 58.104).

The *Quality Standards of the Architectural Woodwork Manufacturers Association of Canada, 1972* stated that when no species of wood is specified, an edge-grain clear fir, hemlock, clear pine or yellow cedar should be used in wood sash manufacture (Millwork, p. 79).

3.2 SEASONING

Many techniques have been used in the past for seasoning timber: immersion in running water or in ponds, boiling and steaming and air drying. The English practice in 1860, related in *The Builder's Practical Director*, is probably representative:

> Timber imported is generally formed into floats on the Thames and elsewhere, as the running water dilutes and washes out the juices in penetrating all the pores. As the water also does not contain any quality to produce fermentation and is easily evaporated, the timber is greatly improved for building purposes. It should be thoroughly dried before being taken to the pit to be sawn (Payne, pp. 151-52).



Various Methods of Stacking Timber (after Payne)

A second stage in the process involved stacking in a yard:

> Timber should be removed to a dry, airy and well-drained situation, and be so stacked that the air may circulate freely round each piece; but it ought not to be exposed to strong currents, or the heat of the sun: the timber yard is preferable if strewed with ashes or scales from a foundry (Payne, p. 140).

4.0 SHOP PRACTICE

4.1 SETTING OUT THE MEASURING ROD

Sash making, like all framed joinery, is preceded by preparing a measuring rod, upon which the various dimensions are laid out. The steps followed in laying out a rod for a 610 mm x 914 mm (2 ft. x 3 ft.), six-light casement sash are described in the *Handbook of Doormaking, Windowmaking, and Staircasing.* For the purposes of clarity the example uses separate height and width rods. In practice the two sets of dimensions would have been set out on different sides of the same rod.

The ICS Reference Library publication, *Carpentry, Joinery…*, contains a somewhat similar description of setting out a rod (p. 10.41). The only significant difference in the two descriptions, beyond the fact that different types of sash were chosen for the examples, is the layout of marks on the rods themselves. In the ICS example, one rod face has been divided down the centre and width dimensions were laid off on one side and length dimensions laid off on the other.

4.2 CONVERTING DEAL TO SASH STUFF (STOCK)

The first task of the joiner in fabricating a window sash was converting stock deal (76 mm x 229 mm) to sash stuff. Certain sizes for sash members were adopted as standards because of strength requirements and the amount of waste they produced when cut from the deal. This is a subject dealt with in the *Handbook of Doormaking, Windowmaking, and Staircasing*:

> The sizes of the various parts of sashes vary very much: if the ready-worked stuff has to be used, as is usually now the case, the sizes are, of course, already settled; but if it has to be ripped out and planed up, we can please ourselves, and suitable sizes will be found to be 2 1/4 ins. wide for the stiles and top rail, 4 1/2 ins. wide for the bottom rail, 3/4 in. thick for the bars, and 1 1/4 ins. for the meeting rails. The above sizes will cut out of the stock 9-in. deals without waste, and will make strong sashes, whether 1 1/2 ins. or 1 3/4 ins. (Talbot, pp. 135, 137).
>
> • • • •
>
> The deal was cut to length with a crosscut saw, to width with a rip saw. Long boards were usually laid over a pair of sawing-stools or saw horses for ripping down (Ward, Lock & Co., Ltd., pp. 219-20).
>
> • • • •
>
> Planing up was done on the bench top. The stuff was laid flat and pushed against the "board catch" or hook for planing. The board catch projected about half an inch above the top and caught the stuff near its under edge and so resisted the forward push of the joiner's plane (Mercer, pp. 69-71).
>
> • • • •
>
> The faces and edges were roughly surfaced with a jack plane. A trying plane was next used to perfectly level "shoot" the edges and smooth the surfaces (Mercer).

The facing up and gauging operations yielded sash stuff of the correct thickness.

4.3 SETTING OUT AND GAUGING THE STILES, RAILS AND SASH BARS

The process of transferring the information on the measuring rod to the various sash members was discussed in the *Handbook of Doormaking, Windowmaking, and Staircasing*. It is the only comprehensive description of this stage of the work to be found.

Once the setting out of the rails, stiles and sash bars had been completed, attention was turned to gauging for mortises and tenons. A mortise gauge was set to the chisel which came nearest to a third of the thickness of the stuff (Talbot, p. 28). The 11 mm and 14 mm would be as a rule correct for 38 mm and 44 mm thick, finished sash. In most cases the mortises would be made in the centre.

> The mortise gauge should be set so that one line comes to the edge of the moulding, and to suit the width of a chisel, always remembering to leave a good rebate. The proportions shown in sections a & b are about right, the dotted lines in the former showing the position of the mortise (Talbot, pp. 114-15).

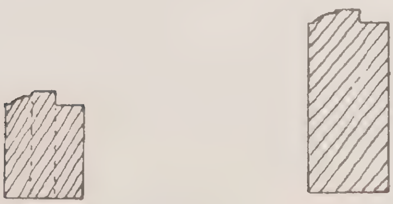
The rails were gauged for tenons and mortises while the bars were gauged for mortises only. No step by step description of gauging the various sash members has been located. A description of a mortise gauge is provided in 2.0 above.

Left, setting out the stiles and upright bar from height rod.
Right, setting out of rails and cross bars from width rod (after Talbot)

4.4 CUTTING STUFF TO LENGTH

Once the setting and gauging of the sash stuff was complete, individual members could be cut to length:

> ...all the rails should be cut $^1/_2$ in. longer than the width of the sashes, while the stiles should be cut about 4 $^1/_2$ ins. longer than the height as shown by the rod (Talbot, p. 139).



Sections – Stile & Top Rail, Bottom Rail (after Talbot)

4.5 CUTTING THE MORTISES

After setting out and gauging the members, including the mortise marks, the mortises were cut. Within the last 100 or so years, the technique for cutting and excavating the mortise has involved boring with an auger or brace and bit and intercutting and squaring up with a firmer (Mercer, p. 165). A modern description of the operation can be found in *Fine Woodworking Techniques* (Frid, pp. 96-101). Before this technique was adopted, joiners cut mortises with a mortise chisel and mallet. A description of the operation was given in the *Amateur Carpenter and Builder*:

> In cutting a mortise, the chisel is grasped firmly by the left hand, and held in a nearly upright position. The wood is in all cases cut by the chisel across the grain, and the operator must take care to remember that the flat part of the chisel must always be turned towards the end of the mortise, and the bevel towards the middle. Thus in cutting a mortise, the position of the chisel in the hand must be continually changed, the bevel being towards or turned from the operator, according to circumstances. The chisel is of course struck by a mallet held in the right hand. In cutting a mortise there is no necessity to make any cut with the chisel in the direction of the grain, all that need be done is to keep working by cuts at a short distance from each other, across the grain, beginning in the centre of the wood to be removed, and proceeding both ways from the centre to either end. It will be found that the wood will come clean out of the cavity without any cutting along the sides of the mortise (Ward, Lock & Co., Ltd., pp. 165-66).

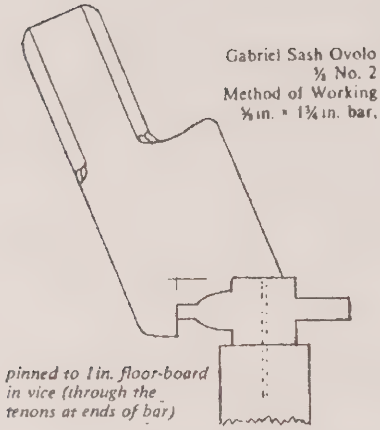
4.6 PARTIAL CUTTING OF THE TENONS

Before working on the sash stuff, it was necessary to make a few last cuts on the tenons. In the case of the rails the cheeks of the tenons only were cut. A variety of saws were used: frame saw, dovetail saw, back saw or ordinary rip saw.

In the case of the sash bars, the procedure was reversed and only the shoulders were cut.

4.7 WORKING THE BARS

After setting out, gauging and cutting the mortises and shoulders of the tenons, the bars were rebated and moulded.



Sash Bar Pinned (through the tenons) to Floor-Board (after Goodman)

FIG. 31.—BAR IN POSITION FOR MAKING FIRST REBATE.

FIG. 32.—BAR REVERSED FOR SECOND REBATE.

FIG. 33.—BAR MOULDED ON ONE SIDE.

FIG. 34.—BENCH KNIFE.

Bar in Position for Making First Rebate; Bar Reversed for Second Rebate; Bar Moulded on One Side; Bench Knife (after Talbot)

A variety of tools and techniques were employed. Five different methods are described below:

Method 1. Working the rebate with a rebate plane, standing or moving fillister. Sticking the moulding with a sash moulding plane.

This method involved four separate planning operations and turning the bar end to end or upside down between each operation.

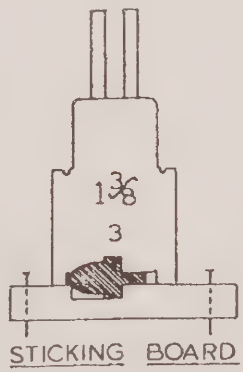
Method 2. Working the rebate with a sash fillister, sticking the moulding with a sash moulding plane. By working the rebate on the far corner, and sticking the moulding on the near corner, this method reduced the number of turning operations.

Method 3. Working the rebate and moulding with a single or double sash plane. By simultaneously cutting the rebate and the moulding, this method simplified the operation to two steps.

These three methods could be carried out by simply pinning the bar through the tenons at each end to a length of floor-board, which in turn would be gripped by a vice.

Method 4. Working the rebate with a sash fillister; sticking the moulding with a sash moulding plane; using a sticking board. This method is similar to the second method, but uses the sticking board.

Method 5. Working the rebate and moulding with a single or double sash plane and sticking board. This method is similar to the third method, but uses the sticking board.



Sticking Board (after Graham)

4.8 WORKING THE RAILS AND STILES

After cutting all mortises on the rails and stiles and the cheeks of the tenons on the rails, the sash stuff was rebated and moulded. A variety of tools and techniques were employed. Three of the more widely used methods are described below.

Method 1. Working the rebate with a rebate plane, standing or moving fillister, sticking the moulding with a sash moulding plane. The first pass was with the rebate plane.

The workpiece was next released, turned end for end and regripped. A second pass was then made using a sash-moulding plane. The plane was tilted or sprung during working using lines scribed on the toe and heel as a guide (each plane was designed to function at a set spring angle which varied between 30° and 45°) [Vandal, p. 73]. An astragal and hollow, ovolo or other moulding was stuck on the face edge of the workpiece.

Sash planes which worked down the edges of sash stuff, rather than down the sides, have been identified by W.L. Goodman in his article (Goodman, pp. 53-55). The steps followed in sticking a moulding with these planes is also described.

Method 2. Working the rebate with a sash fillister; sticking the moulding with a sash moulding plane. By working the rebate on the far side of the face edge and sticking the moulding on the near side, the work did not have to be turned.

Method 3. Working the rebate and moulding with a single or double sash plane. A single pass was made with the sash plane, simultaneously cutting the rebate and moulding on the face edge.

4.9 FORMING THE TENONS AND SCRIBING THE MOULDING OF THE SASH BAR

After sticking the rebate and moulding on the sash bar, the joiner completed the tenons and scribed the moulding to the counter profile of the sash stuff against which it would fit.

A 1/2" [13 mm] deep stub tenon was generally used for sash bars (International Textbook Co., p. 10.41). The shoulders of the tenons having been cut earlier, it was only necessary to cut the cheeks. The moulded and rebated sites of the sash bar were cut back with a chisel (Talbot, p. 118) or rebate plane (Graham, p. 35).

Sash bars have been scribed or coped using a variety of tools and techniques. A description of three methods follows:

Method 1. Sash scribing plane and saddle templet. The bar was stood in a saddle templet and the shoulder on the moulded side of the tenon cut with the scribing plane laid flat, using the side of the tenon as a guide. The saddle templet, being an exact reverse of the moulding section, supported the wood of the sash bar and so helped to avoid splintering out the end grain of the wood.

A double sash coping plane which cut a similar coping with the bar and templet in a horizontal position is also known (Baldwin Tool Co., p. 17). The probable method of handling the tool is illustrated in a 1978 article by Robert Graham (Graham, p. 35).

According to the late A. Collier, a British collector, the use of planes for scribing was discontinued in England after about 1890 (Salaman, p. 355).

Method 2. Scribing gouge and templets. Unlike the procedure described in the first method, scribing with a gouge first required the mitring of the shoulder on the moulded side of the tenon. A side or single sash templet was held against one side of the sash bar and a mitre cut with a chisel. The procedure was then repeated for the opposite side (Talbot, p. 118).

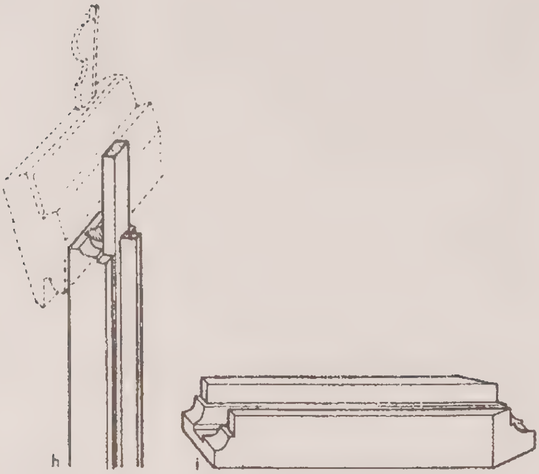
A saddle templet with one end mitred on each corner was also used for mitring. It was laid over the sash bar and the projecting part of the moulding pared down flush with the mitre on the templet on each side (Salaman, p. 482).

The workpiece was then laid in a saddle templet, with the end cut square and shaped to the counter-profile of the moulding. A scribing gouge was then pushed by hand or shoulder pressure through the fibre which cut the surplus away.

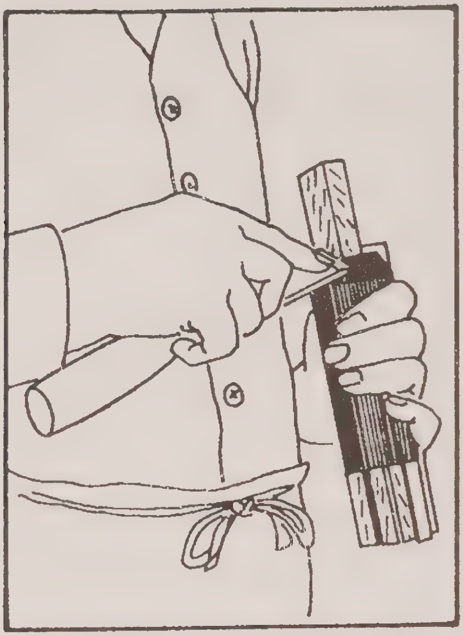
Method 3. Coping saw and templets. The mitring procedures outlined in the second method was again followed. This gave an exact marking of the amount of material to be removed. A coping saw was used to cut the surplus away. The coping saw, as we know it today, appeared about 1920 [Salaman, p. 413]. As a means of scribing the counter-profile of the moulding, it eventually superseded the use of the sash scribing plane.

4.10 FORMING THE TENONS AND SCRIBING THE MOULDING OF THE RAILS

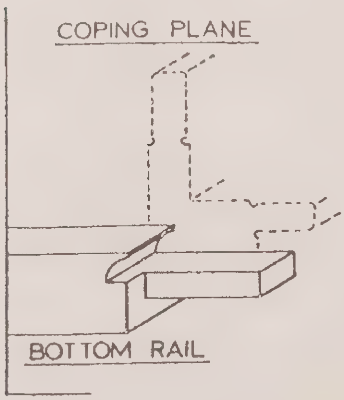
After sticking the rebate and moulding on the sash stuff, the joiner returned to the rails, completing the tenons and the scribing of the moulding to the counter profile of the stiles against which they would fit.



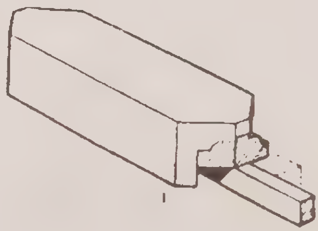
Sash Scribing Plane Working Sash Bar in Saddle Templet; and (h) Combined Mitre and Scribing Saddle Templet (i) (after Salaman)



Mitring Sash Moulding for Scribing (after Talbot)

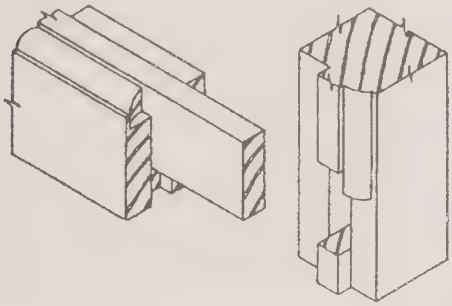


Double Sash Coping Plane Cutting a Bottom Rail in Horizontal Position (after Graham)



Mitring Sash Bar Using Saddle Templet (after Salaman)

After having sawn in the tenons on the rails, it was now necessary only to cut the shoulders and haunch the tenons. The shoulders were cut using a tenon saw. The cut was made up to the mark but not on it (Talbot, p. 30). After this, the haunchings were cut out, not as solid pieces, but as wedges to use in wedging up the window when done.



Hand-Scribed Mortise and Tenon (after Kelsey)

The top and bottom rails of window sash have been scribed in a variety of ways. The methods are similar to those used for the sash bars, but adapted to the larger stock.

4.11 JOINTING THE SASH BARS

Historically, a number of techniques have been used to joint intersecting sash bars in a multi-lighted sash. Halving, franking, franking and halving and dowelling were all used (see Definitions, "Franking" above). Franking, by far the most common, and dowelling, one of the oldest techniques, are discussed next. For the purposes of illustration, a casement sash, with continuous cross bars is assumed. Jointing sash bars was not an operation done in isolation. Work such as cutting mortises, forming tenons, or scribing the mouldings was performed at the same time as work on the sash stuff generally. The grouping of the various stages of the work under the headings below is for explanation only and not an additional joinery operation.

Jointing Sash Bars by Dowelling (a) cross-section: and (b) elevation (after Nicholson)

Franking

The mortise was cut through the cross bar, the whole width of the square part (see 2.0 above, "Franking"; for sequencing and technique see 4.5 above, "Cutting the Mortises").

The long upright bar was sawn apart on the centre line of each cross bar (for sequencing and technique see 4.4 above, "Cutting stuff to length").

The shoulders of the tenons on the ends of the upright bars were cut (for sequencing and technique, see 4.6 above, "Partial cutting of the tenons").

Following rebating and moulding of the sash bars, the cheeks of the tenons on the upright bars were cut back and the shoulders on the moulded side of the tenon scribed. (For sequencing and technique, see 4.9 above, "Forming the tenons and scribing the moulding of the sash bar"). The completed upright bars were secured in place by the pressure of the rails of the sash against the outer ends of the upright bars.

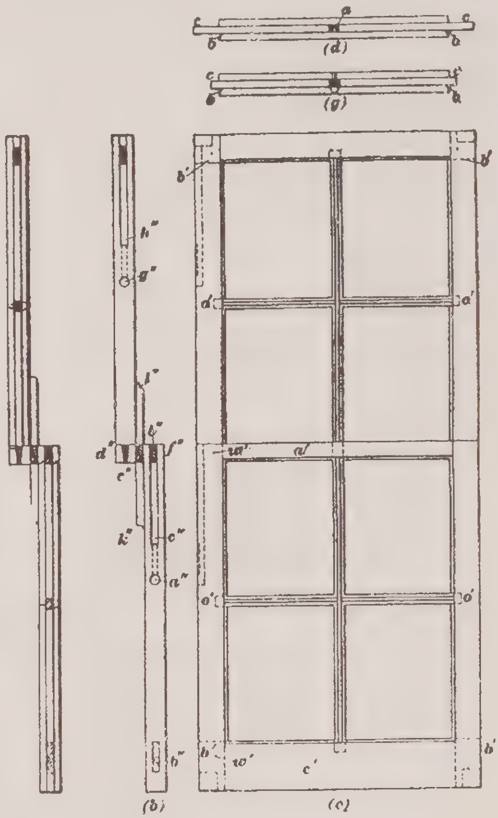
Dowelling

Until the middle of the 19th century, intersecting sash bars were generally dowelled together. No detailed description of the steps involved in making the joint has been located. What does emerge, however, is that up to and including the rebating and moulding of the sash bars, the technique generally followed that described under "Franking." At this stage the cheeks of the tenons on the upright bars were cut back and the shoulder on the moulded side of the tenon mitred. "V" shape excavations were made in the cross bar where it was intersected by the upright bars. The upright bars were laid in a sash dowelling box and holes bored in the end of the tenons. An appropriate diameter dowel, placed in the upright bars, completed the connection.

4.12 FINAL ASSEMBLY

A general description of the final assembly procedures for a pair of four light double hung sash is provided by the 1904 ICS Reference Library text No. 14. In the example discussed the cross bars are tenoned into 13 mm deep mortises in the stiles. The description could equally describe a casement sash:

> When all the parts of a sash are made – stiles, rails, vertical and horizontal bars – the whole frame is drawn together with bench clamps, and wedges dipped in glue are driven in on each side of the tenons.... The mortises are made 1/2 inch wider on the outside than on the inside of the stiles, to make room for the wedges, which are driven until the joint is closed tight (ICS Reference Library, p. 10.44).



Sections, Elevations, Double Hung Sash, Four Light (after International Textbook Co.)

The final assembly procedures for a six light casement sash is provided in the *Handbook of Doormaking, Windowmaking, and Staircasing*. The cross bars in the example used are through mortise and tenon jointed to the stiles.

> When ready, all parts should be fitted together, then, if correct, knock off the stiles about half way, glue

the tenons and shoulders quickly and liberally, cramp up at once, and wedge tightly. Each sash must be tested with the squaring rod diagonally before the wedges are driven home.

The tenons of the rails should all be wedged first, leaving the bars to be done after. When doing the latter, keep an eye on them, or the wedges may force them to one side, making them crooked. This is easily obviated by driving the wedge at one side or the other as required (Talbot, pp. 119-20).

4.13 REINFORCING THE JOINTS

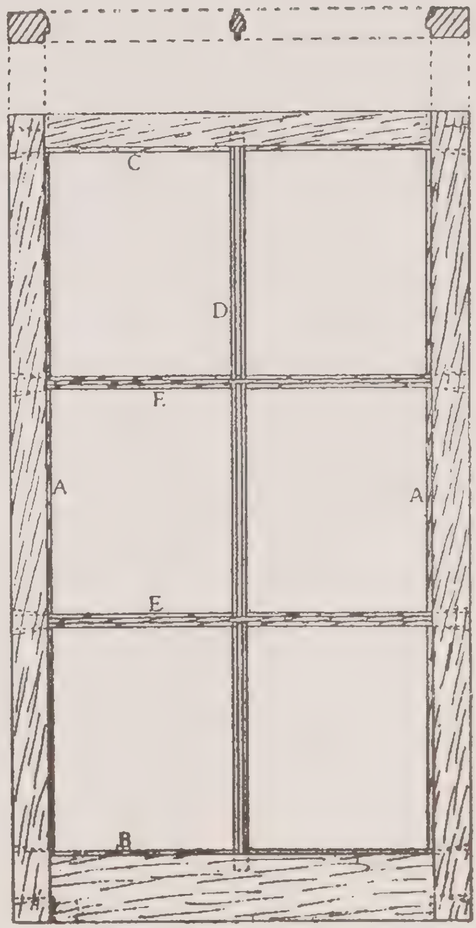
The stresses imposed on an operating sash often weakened the mortise and tenon joints. As a result, the joiner often reinforced the joints with hardwood pins. Number 14 of the ICS Reference Library, is one of the few texts which referred to the practice:

> Hole 1/4 inch in diameter are now bored through each mortise and tenon and each dovetail joint, and wood dowels dipped in glue are driven through the joint to secure it in the elevation. Barbed steel or iron pegs are often used instead of wood dowels (p. 10.44).

A detailed examination of pinning and wedging generally is found in the previous section (8.1) "Door Making" and is not repeated here.

4.14 FINAL FINISHING

When the clamps were removed, the faces were smoothed and made ready for fitting into the frames (ICS Reference Library, p. 10.44).



Elevation, Casement Sash (after Talbot)

5.0 BIBLIOGRAPHY

Arnold & Walker. 1978. *The Traditional Tools of the Carpenter and other Craftsmen.* Catalogue No. 6. Arnold & Walker, Suffolk.

Bailleul, E., and J. Heurtematte. 1973. *Cours de technologie professionnelle de spécialité du bois.* Librairie Delagrave, Paris.

Baldwin Tool Co. 1857. *Illustrated Supplement to the Catalogue, and* 1858. *Catalogue and Invoice Price List of Bench Planes and Moulding Tools.* Reprint 1976. Ken Roberts, Fitzwilliam, NH.

Brees, S.C. 1853. *The Illustrated Glossary of Practical Architecture and Civil Engineering: Comprising the Theory and Modern Practice with the Subjects of Office and Field Work.* L. A. Lewis, London.

Burrell, Edward J. 1931. *Elementary Building Construction and Drawing.* Longmans, Green and Co., London.

Canadian Standards Association. 1977. *Wood Windows.* CSA 0132.1-M1977. Rexdale, ON.

Fleming, John, Hugh Honour and Nikolaus Pevsner. 1972. *The Penguin Dictionary of Architecture.* 2nd edition. Penguin Books, Harmondsworth, Middlesex.

Frid, Tage. 1978. "Mortise and Tenon, Choosing and Making this Basic Joint" in *Fine Woodworking Techniques.* Taunton Press, Newtown, CT.

Goodman, W.L. 1983. "Gabriel & Sons, Stock Inventories," *The Chronicle of the Early American Industries Association,* Vol. 36 (September), pp. 53-61.

Graham, Robert D. 1978. "To The Editor," *The Chronicle of the Early American Industries Association,* Vol. 31 (June), p. 35.

Hammond, James J., et al. 1961. *Woodworking Technology.* McKnight & McKnight, Bloomington, IL.

Harris, Cyril M., ed. 1975. *Dictionary of Architecture and Construction.* McGraw-Hill Book Company, New York.

Hodgson, Fred T., ed. 1906. *Carpentry and Joinery.* Vol. 2. Encyclopedia of Carpentry and Contracting. Cree Publishing Company, Chicago.

Holland, Leicester B., and Harry Parker. 1926. *Ready-Written Specifications.* John Wiley & Sons, New York.

Holtzapffel, Charles. 1875. *Turning and Mechanical Manipulation. Intended as a work of general reference and practical instruction on the lathe, and the various mechanical pursuits followed by amateurs.* Holtzapffel & Co., London.

Hummel, Charles F. 1968. *With Hammer in Hand, The Dominy Craftsmen of East Hampton, New York.* University Press of Virginia, Charlottesville, VA.

ICS Reference Library. 1904. *Carpentry, Joinery, Stair Building, Geometrical Drawing, Architectural Drawing, Estimating and Calculating Quantities, Specifications.* No. 14. International Textbook Co., Scranton, PA.

Kelsey, W. Eric. 1974. *Building Construction.* David and Charles, Newton Abbot, Devon. Quoted material and illustrations reprinted with permission: David and Charles.

Lee Valley Tools. 1979-80. *Catalogue.* Lee Valley Tools, Ottawa.

Lowndes, Wm. S., and David B. Emerson. 1926. *Specification Writing: Architects' Blueprints and Specifications.* International Textbook Co., Scranton, PA.

Macey, Frank W. 1922. *Specifications in Detail.* 3rd edition revised. Crosby, Lockwood and Son, London.

Mercer, Henry C. 1951. *Ancient Carpenters' Tools, Together with Lumbermen's Joiner's and Cabinet Maker's Tools in Use in the Eighteenth Century.* Bucks County Historical Society, Doylestown, PA.

Millwork Contractors Association. 1972. *Quality Standards of the Architectural Woodwork Manufacturers Association of Canada.* Revised. AWMAC. Millwork Contractors Association, Burnaby, BC.

Nicholson, Peter. 1840. *Nicholson's Practical Carpentry*. Revised by Thomas Tredgold. Thomas Kelly, London.

Payne, A.H. 1860. *The Builder's Practical Director*. A.H. Payne, Leipzig, GER.

Ramsey, Charles George, and Harold Reeve Sleeper. 1956. *Architectural Graphic Standards*. 5th edition. John Wiley & Sons, New York.

Roberts, Kenneth D. 1967. "Wooden Planes – Some Basic Definitons, Part III Rabbet and Sash Planes," *The Chronicle of the Early American Industries Association,* Vol. 20 (June), pp. 22-24.

Salaman, R.A. 1975. *Dictionary of Tools used in the woodworking and allied trades, c. 1700-1970*. George Allen & Unwin, London.

Scott, John S. 1974. *A Dictionary of Building*. 2nd edition. Penguin Books, Harmondsworth, Middlesex, UK.

Sellens, Alvin. 1978. *Woodworking Planes, A Descriptive Register of Wooden Planes*. Alvin Sellens, Augusta, KS.

Sloane, Eric. 1964. *A Museum of Early American Tools*. Ballantine Books, New York.

Sutcliffe, G. Lister. 1899. *Windows, Doors, Skirtings, and Stairs: The Principles and Practice of Modern House Construction*. Blackie & Son, London.

Talbot, Antony, ed. 1980. *Handbook of Doormaking, Windowmaking, and Staircasing*. Sterling Publishing Company, New York. Quoted material and illustrations reprinted by permission of Sterling Publications Co., Inc. © 1980, Argus Books Ltd.

Vandal, Norman. 1982. "How to Make a Molding Plane, Sticking with an 18th Century Tool," *Fine Woodworking,* No. 37 (Nov.-Dec.), pp. 72-77.

Ward, Lock & Co., Ltd. ca. 1880. *The Amateur Carpenter and Builder*. London.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

8.3

PERIOD JOINERY

PANELLING, FITTINGS AND DECORATIVE WORK

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: D. BOUSE/G. SHEMDIN

CONTENTS

1.0 INTRODUCTION

The realm of the joiner was described in the International Library of Technology's *Masonry, Carpentry, Joinery: The Art of Architecture, Engineering and Construction* in 1899 as follows:

> Joinery, as distinguished from carpentry, relates to that branch of the woodworking trades which deals with those internal and external fittings of a house that are put in place after the rough framework and flooring are finished, such as the floors, skirtings, casings, wainscotings, doors, windows, paneled partitions, stairways, etc.
>
> In joiner's work, close-fitting joints, accurate workmanship and smooth finished surfaces are the chief points in view, as contrasted with the work of the carpenter, whose main object is to provide a frame or skeleton which shall be strong enough to resist any stress to which the building may be subjected and arranged to comply with the requirements of the finished joinery.
>
> Hence, while the latter deals principally with heavy timbers in the rough, the former uses smaller pieces of finer and more carefully seasoned woods and joins and fits them with the utmost accuracy. The joiner, therefore, must work with much more care and to a higher degree of finish than the carpenter. All the surfaces he leaves exposed must be smooth and clean, ready for the finisher.
>
> His time is spent between the duties of the workshop and the building. In the workshop, he prepares the framed and paneled work, door frames and casings, window frames and sash, all classes of molded work, the various parts required for stairways, general trim and interior fittings. In the building, he attaches the finished woodwork to the framed base, consisting of false jambs, furring strips and grounds, all of which the joiner should verify as to correct leveling, plumbing and alignment before he applies the materials. True, these should have been placed correctly by the carpenter, but the careful joiner will always make an examination of existing conditions, so that he may better meet them intelligently.

This article covers panelling, fittings and decorative work. It focuses on the kinds of fittings usually found in residential work.

Stylistic influences on panelling, fittings and decorative work vary with time, geographical location and cultural group. Technological conditions have affected the material and the nature of connections employed in assembly.

MacRae, and Adamson, p. 178

2.0 CONNECTIONS AND MATERIALS

2.1 MATERIALS

Wood, the raw material for joiners' work, was cut into boards by different means. Before saw mills became common in the late 18th century, boards were either riven (i.e. split) or pitsawn by hand. Up until the third quarter of the 19th century, the rough-sawn lumber was planed smooth using hand planes. Any desired mouldings were also applied using hand planes.

"Duldregan" (MacRae and Adamson)

At that time planing mills began to appear in urban centres. From this point on the need to dress lumber by hand steadily decreased except in remote areas.

Towards the end of the 19th century and into the 20th century, straight-grained clear lumber became somewhat scarce and relatively more expensive. For this reason, where larger cross-sections of wood were required, they were sometimes built up by nailing smaller sections or gluing together. These built-up sections were frequently covered in applied woodwork to create the illusion of a larger section.

Wooden elements were usually made from softwood, most often pine, which was then painted, stained or, in some situations, covered by a hardwood veneer. Because of the expense and difficulty in working hardwoods, they were used by the most skilled joiners in only the most important reception rooms or in lathe work where the dense grain was an advantage. Secondary elements which did not show (e.g. the sides and bottoms of drawers in built-in cupboards) were almost always softwoods.

2.2 JOINTS

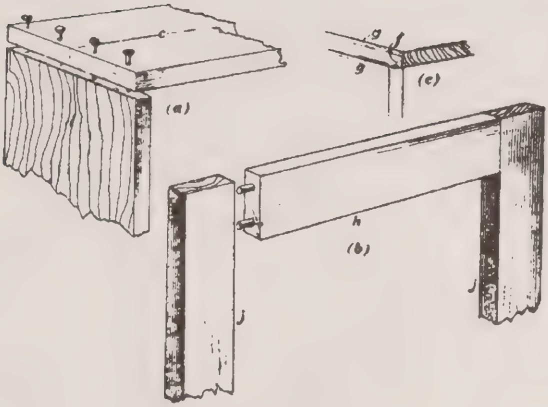
In joinery various types of connections or joints were used to fasten elements together. Their forms ensured that the strains to which they were subjected were either resisted or compensated. Generally in the 18th century and the first three quarters of the 19th century, traditional connections such as mortise and tenon, dovetails and tongues and grooves were used exclusively. Except in cheap or rudimentary work, nails were used only to fasten the assembled element to the building or to fasten applied trim or mouldings. Most of these traditional types of connections recognized and allowed wood to swell and contract with changes in humidity.

Towards the end of the 19th century and into the 20th century, traditional connections started to go by the wayside in the interest of faster, more economical methods. These faster methods tended to rely more on glue, nails and dowels and tended to ignore the expansion and contraction of wood.

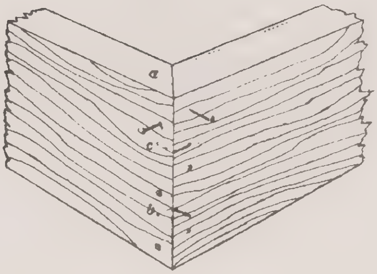
The following are the principal kinds of joints used a century ago. (The descriptions have been abridged from *Masonry, Carpentry, Joinery: The Art of Architecture, Engineering and Construction in 1899*.) Some were traditional connections and others were newer ones which were beginning to replace them.

In joiners' work, the joints may be divided into two classes, namely *loose* joints and *glued* joints. The former consisted of two or more pieces held in place by the shape of the parts of union, such as the dovetail joint. In the latter, the pieces were secured by glue, as in the mitre joint and the halved corner.

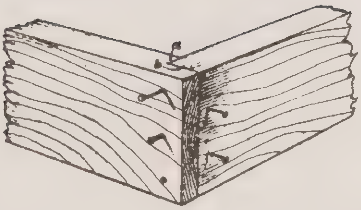
Loose joints were seldom used in joinery, except in heavy machine frames, in pieces of cabinetwork which are made in sections for convenience of handling or in the exterior finish of



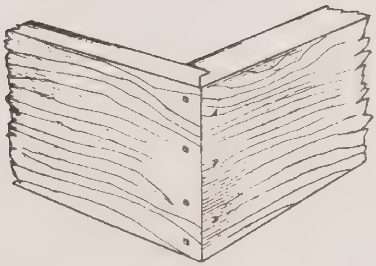
Butt joint



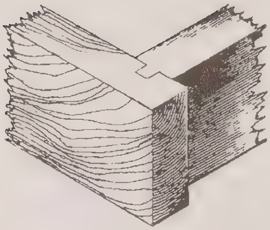
Shouldered corner



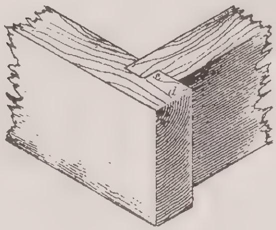
Mitre joint



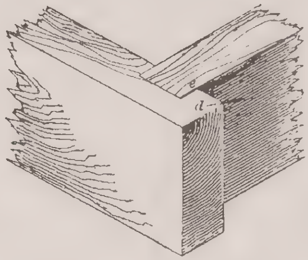
Shouldered-and-mitred joint



Tongue-and-groove joint



Dado joint



Housed joint

a building where exposure to the weather rendered the glued joint unreliable. In any case, the loose joint was usually made additionally secure by using screws, nails or wooden pins.

Glued joints required some mechanical contrivance to hold them in position while the glue set, which usually required from twenty minutes to four hours, according to the quality of the glue, the condition of the atmosphere and the temperature of the room.

The simplest joint was the *butt joint*. The two pieces joined were simply butted together, in a similar manner to the butt joint in carpentry. However, the adjacent surfaces were much more accurately fitted and were held in place by screws or dowels – the former when the pieces joined were broad and thin and the latter when the timbers were heavy and thick or when they were joined together on the thinner edges.

The joint was insecure in itself and usually required glue to make it reliable; or it may have been kept in place by the woodwork behind, against which it was erected.

The *mitre joint* was generally used when the boards were the same thickness, where great strength was not necessary and where it was required that the angle not show an end grain of the wood, either inside or outside of the joint. It was usually nailed or screwed together as shown, but depended upon glue to secure it; or it was strengthened by a slipfeather or spline. It was also sometimes secured by gluing in a key of thin wood, which was inserted in a saw kerfed out diagonally or at right angles to the end. A keyed mitre was generally used for a joint seen only from the interior, because the keys disfigured the exterior appearance. This joint was also made with the broad portion of the wood on the face, as in the case of architraves and casings.

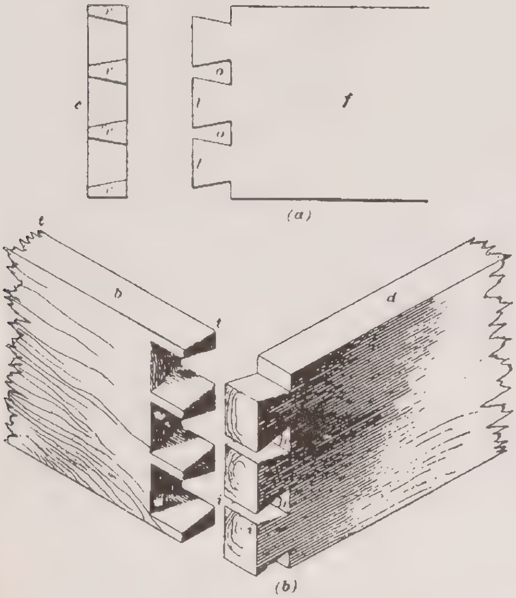
The *shouldered corner* was a joint used where the inside angle alone would have been visible and was an improvement on the butt joint because it provided two nailing surfaces.

The *shouldered-and-mitred joint* was a combination of the mitre joint and the shouldered corner. It had the advantages of showing no end grain, as did the shouldered corner and possessed the additional strength gained from the method of joining the pieces of the same. Its use, however, was limited to light work, where great strength was not required between pieces of unequal thickness.

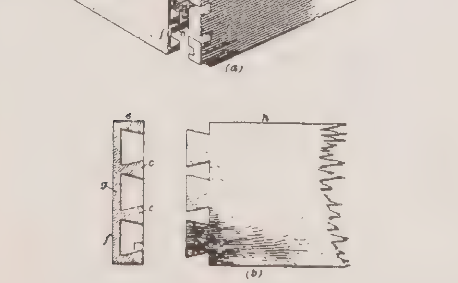
The *tongue-and-groove joint*, the *dado joint* and the *housed joint* were modifications of the same form: the end of one piece was let into the side of another piece about one third of its entire thickness. These joints were frequently used in joinery. They were secured by glue, nails or screws or may have been left loose to allow the members to come and go in shrinking and swelling.

The *dovetail joint* was one of the most important in joinery. It furnished a rigid method of securing pieces together where the fibres of the material were approximately at right angles with the joint. The strength of the entire joint depended upon the combined value of the dovetails, the same as a nailed joint depended upon the combined resistance of the nails. Another factor entering into the strength of a dovetail joint was the adhesive strength of the glue binding the fibres of the projections on the united pieces.

There were three kinds of dovetail joints. The common form, known as U, had its dovetails and its dovetail pins projecting from the body of the piece *b* a distance equal to the thickness of the piece *d*. The ends of the pins and dovetails showed on opposite sides of the corner when the pieces were joined.



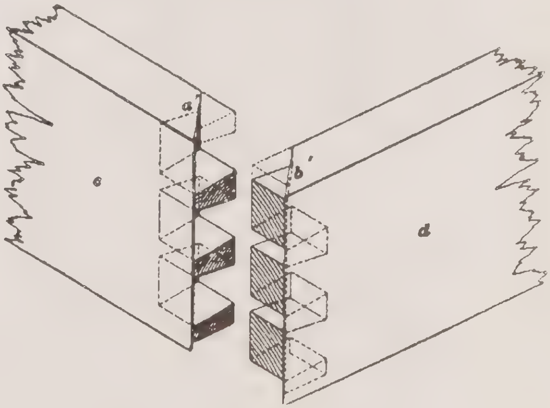
"U" Dovetail Joint



Half-lap Dovetail

Another form, known as the *half-lap dovetail*, was a joint in which the pins *e* have, as at *f*, *g*, a lap which, when the joint was closed, covered the end of the dovetails on *h*. This joint was well adapted for drawer fronts, as shown at (a), as the piece *c*, which showed no dovetails, formed the drawer front and the ends of the dovetail pins, on the side piece *h* were hidden when the drawer was closed. The side elevation of the joint and the relative size of the dovetails and dovetail pins are shown at (b).

The third form was known as the *blind* or *secret dovetail*. In this joint about three-fourths of the thickness of the board was dovetailed, with the remaining portion united in a mitre joint. Both the dovetails and the dovetail pins were cut only partially through the board and the upper pin *a* of the piece *c* is cut off the mitre line of the angle, while the upper half mortise *b* is cut only to the mitre line of the piece *d*, thereby concealing entirely the details of the true character of the joint, when the pieces were united.

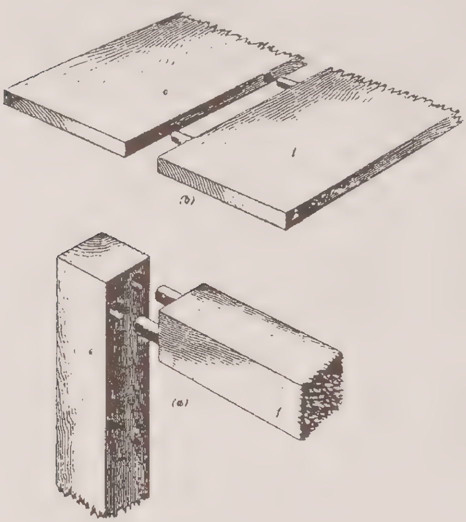


Blind or Secret Dovetail

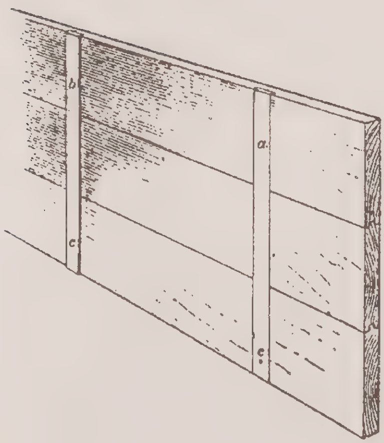
The *dowelled joint* consisted of a plain butt joint between the two pieces *e* and *f*, either between one end and a side as at (a) or between the two meeting edges, as at (b). Holes were bored and dowels were glued and inserted as shown. The object of the dowel was to keep the faces flush and render the joint stiffer if subjected to a transverse strain. The holes should have been somewhat deeper than the length of the dowels, to allow for shrinkage of the material and at the same time insure a close joint.

The *mortise-and-tenon joint* as used in joinery was precisely the same in principle as the same joint in carpentry, but the fitting was much more accurate. This joint, in varied forms, was

used to secure the rails and stiles of doors and windows, to unite the members of heavy machine frames and to connect the various parts of tables, chairs and other pieces of furniture.



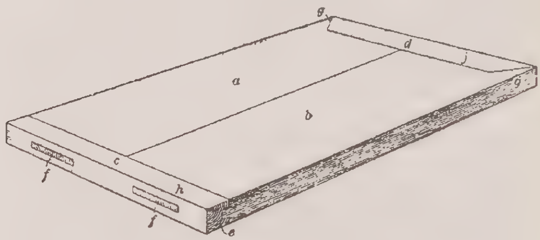
Dowelled Joint



Keys

When broad, plain surfaces, such as dados, window backs and table tops were required, the boards forming them were generally tongued-and-grooved together or they were dowelled and united with glue. But, to secure the surface against warping or twisting, pieces of wood called *keys* were let into a dovetailed groove in the back, as shown at *a*. These keys were either planed off flush with the surface into which they were sunk or, when extra strength was required, they may stand up from the back, as shown at *b*. They were not glued in position, but were sometimes secured with a single screw or nail at one end, as shown at *c*, so that when the material shrank it would slide upon the key and the joint along the keyway or groove would remain tight.

Boards were sometimes kept from warping by *clamping*. The boards *a* and *b* were dowelled or tongued-and-grooved together on their interior edges to form a close joint, as at *c*, *d* and the clamps *i*, *j* were glued over tongues worked on the ends of *a* and *b*, as shown at *c*.



Clamping

In first-class work, tenons *f* were also worked on *a* and *b* and by insertion in the mortises on the clamp *h*, strengthened the joint materially. When it was undesirable to show the end grain of the clamp, as at *c* or of the tenons, as at *f*, the ends of the clamps were mitred off as shown at *g* and the tenons were not permitted to extend entirely through the clamp.

2.3 PROVISION FOR EXPANSION AND CONTRACTION

In a broad surface, such as plain wainscot, this was accomplished by securing only one edge and permitting the other to rest in a groove, so that it could contract as the wood shrank or expand when affected by dampness.

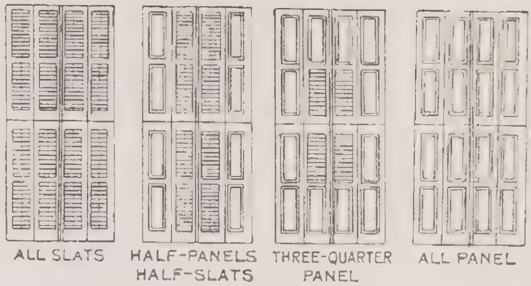
3.0 FITTINGS

The following is a discussion of the principal kinds of fittings and decorative work. Windows and doors are considered in Sections 8.1 and 2 and are not treated here.

3.1 WINDOW SHUTTERS

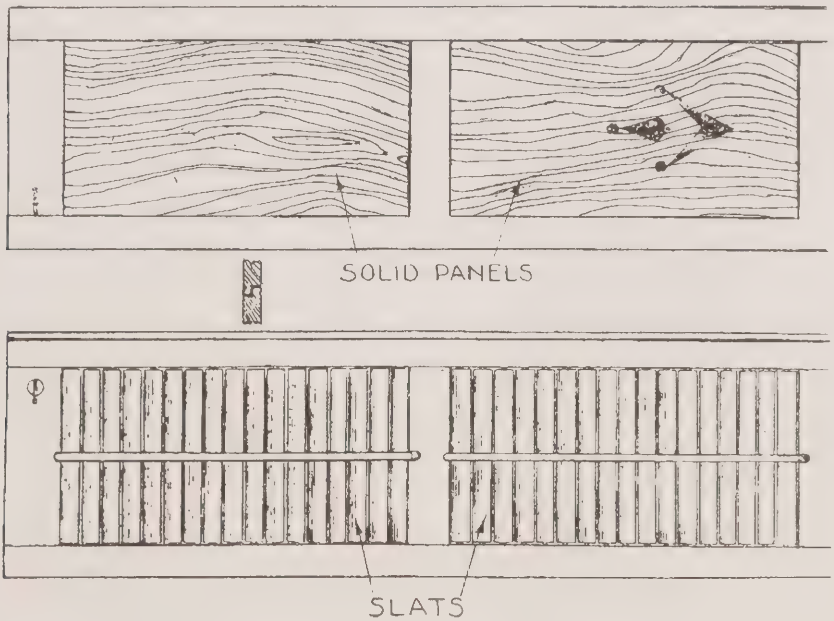
Window shutters or blinds helped to control light, air exchange and security. They were hung on either the exterior window frame (in which case they were called shutters) or on the interior (usually called blinds). They could be blind, i.e. with solid panels in a frame or louvered (slatted) or a combination of blind and louvered sections.

Interior blinds were usually designed so that when closed into their box, the exposed blind showed a panel finish on the inside of the room.

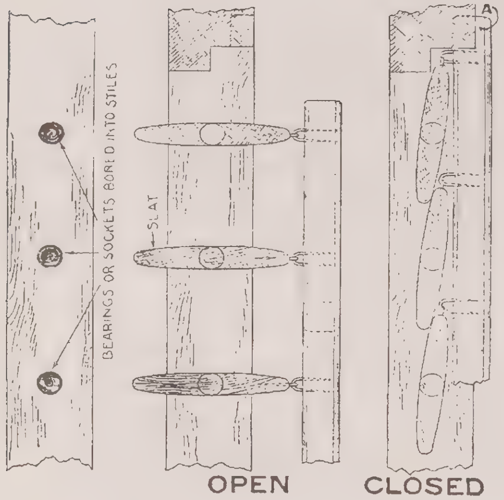


Shutters or Blinds

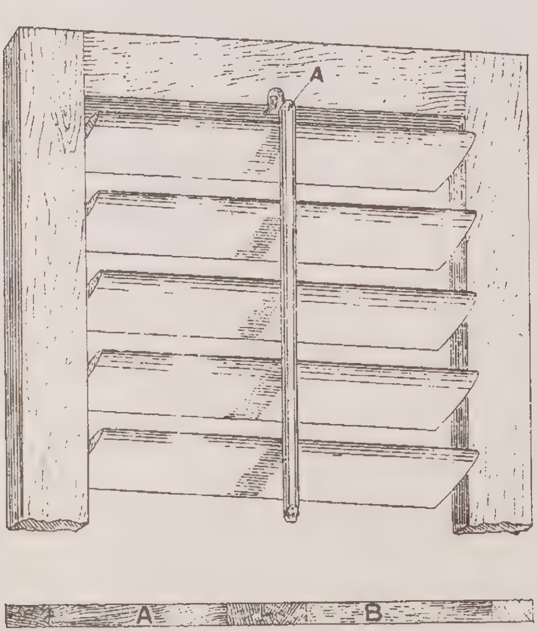
Exterior shutters were generally all panelled in the 18th and early 19th centuries; the louvered type was used throughout the 19th and early 20th centuries. Exterior shutters differed from interior kinds in these construction details which their more exposed situation required.



Solid or slat blinds, sometimes with a design cut in top solid panel and section showing lap joint.



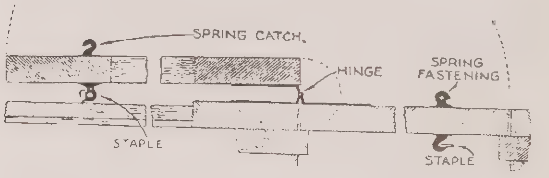
Method of Pivoting and Adjusting Slats Showing Slats in Open and Closed Positions (after Graham).



Portion of slat blind showing slats assembled and plan of pair of blinds showing lap joint at centre (after Graham).

Traditionally the mouldings and panel arrangements in the shutters matched those in doors, wainscotting, chimney pieces and other fittings elsewhere in the room that the same joiner would have made and installed.

By the beginning of the 20th century most shutters were factory-made.



Plan of single blind showing hinge and spring fastening for locking blind in open or closed position (after Graham).

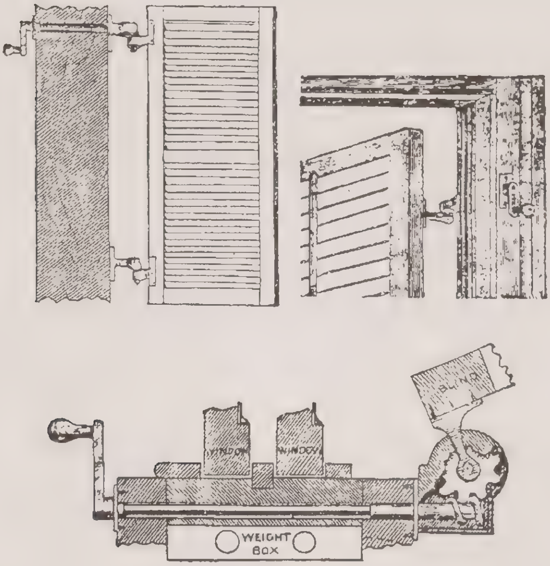
3.2 WAINSCOT

Wainscot (or wainscotting or dado) is a material applied as a finish to the lower part of an interior wall between the chair rail and the baseboard (or skirting). Wood, tile and marble were commonly used. Sometimes the entire wall was covered in a panelled wainscotting, but traditionally wainscotting was constructed from wood up to three to four feet high.

A wooden wainscot usually had a cap and a base. The space between the two was filled with either matched boarding or with panelling. The stylistic development of wainscot is treated in the history of interior design.

The following section from *Masonry, Carpentry, Joinery: The Art of Architecture, Engineering and Construction in 1899*, described how a panelled wainscot was laid out, constructed and installed:

> In a paneled wainscot… great care is necessary in fitting all the joints and due consideration must be given to the subject of shrinkage, so that the subsequent drying out of the material will not cause unsightly cracks or open joints. The vertical pieces *a* and the horizontal members *b*, *b*' and *b*," dividing the surface of the wainscot into panels, called stiles and rails, respectively, are framed and glued together. The panels *c* are left free to shrink or swell to a greater or less extent, without disturbing the surrounding



Inside control for outside blind. It operates the shutter from within without raising sash or screen, and holds it in any position. It can only be moved by the handle. The blind is lifted from the hinges the same as any blind hinge. The sectional view clearly shows its construction and that the only cutting required is to bore a $^{1}/_{2}$ inch hole through the casing which does not interfere with the weights. The continuous cog gear admits of attaching shutter with it in any position (after Graham).

members. The end stiles *a'*, extend from the floor to the top of the top rail *b* and are mortised to receive the tenons of the rails *b*, *b'*, *b*," as shown at *c*, *c'* and *c*." The rails are also mortised and receive the tenons of the short stiles or muntins *a*, *a*," as shown at *f*.

In the edge of each stile and rail a groove is worked to the depth of the molding *g*, and the edges of the panels *c* are beveled off or hollowed out and inserted in this groove, as shown at *h*. The moldings *g* when small may be worked on the edges of the stiles and rails, but when large and heavy they must be worked from separate stock and fitted in position afterwards.

The panels are thus practically separate from the surrounding frame and are free to shrink without danger of splitting. At the same time, since the amount of cross-grain in the extent of the wainscot is equal only to the sum of the widths of all the stiles in one direction and to the widths of all the rails in the other direction, the shrinkable material is reduced to a minimum, so that the wainscot, when constructed with well seasoned material, will give good results.

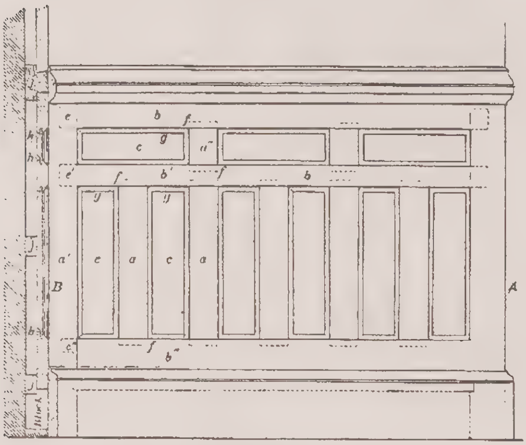
• • • •

After the paneling of the wainscot is completed, it is secured to the grounds, shown at *j*...which were set in place to receive it, before the plastering was applied. Every possible precaution must be taken to insure the drying of the plaster, as the presence of the slightest moisture is fatal to permanent joiners' work.

• • • •

After all the mortises and tenons are cut and fitted and each has been marked so that it can be returned to the same place to which it was fitted, the pieces of wainscot are taken apart and laid in a pile preparatory to gluing. The shoulders and cheeks of the mortises near the shoulders or the tenons near the shoulders receive the glue, and the stiles are forced into the rails as soon after the glue is applied as possible. The lower stiles are glued in the bottom rail first, then their upper tenons are covered with glue in the same manner and the middle rail *b'*, is forced over

them. The upper stiles are then glued into the middle rail; and finally the top rail *b* is glued in place and the whole form is drawn together with bench clamps until the glue is thoroughly dry.



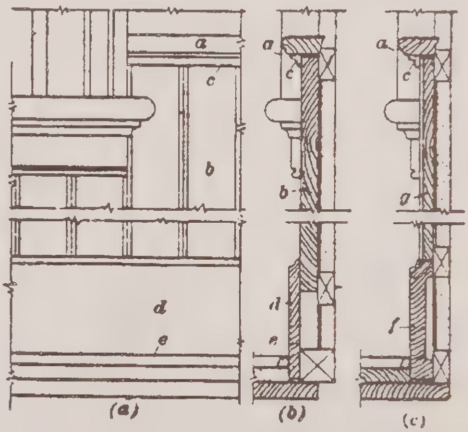
Panelled Wainscot

In all joiners' work, framed together with mortise and tenon, care must be taken to clean out the mortises thoroughly and dust off the tenons before gluing; each tenon must be tried in the mortise to which it belongs and any unevenness removed, to insure its proper fit. All framed work should have its parts heated thoroughly before being clamped and glued together. If, when a piece of work is being clamped up, any rail or stile has a tendency to warp, then that rail or stile must be clamped in place with a bench screw under a piece of thick plank and must so remain until the glue is dry. Care must always be taken that an extreme pressure of the clamps does not cause the work to deflect or wind, as it is exceedingly important in all kinds of paneled work that the whole face of the frame be kept in place, out of wind, until the glue is thoroughly set or dry (International Library of Technology, pp. 16-21).

Prior to about the middle of the 19th century, match boards were hand planed, usually beaded and random width. Frequently they were laid horizontally and, although a cap was used, no shoe mould occurred. Later in the 19th century match boards were run at a mill, usually with a V-groove on the finished side. The following section and accompanying illustration from *Carpentry: Book III (1943)* describes laying out and installing match board wainscotting as it was done in this century:

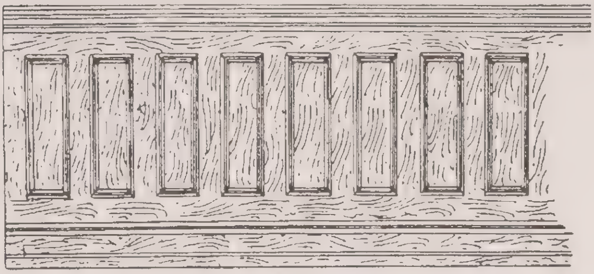
> When matched boarding is used between the cap and base the wainscotting will appear as shown in illustration. In a. the cap is at *a*. The window casings must be thick enough to take the cap as shown in b. and c. In placing this wainscoting as shown in b., the boarding *b* must be set first. The boarding is nailed to the grounds. The cap is then set and leveled. The bed mold *c* is then put in place. The base *d* is next applied directly to the face of the boards and the shoe mold *e* nailed to the floor.
>
> In the method indicated in c., the base *f* is set first and must be level and true. The boarding *g* is cut to fit the base accurately, as the joints between the boarding and the base will show. The cap *a* and bed mold *c* are placed last (Lowndes).

By the late 19th century, panelled wainscot could be ordered factory-made.



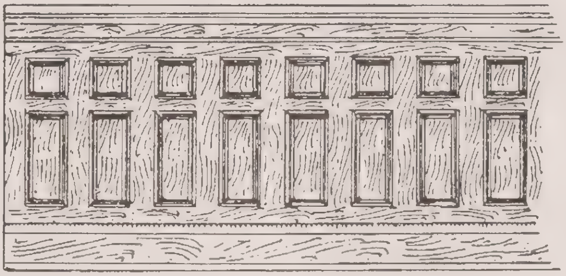
PANELED WAINSCOTING—with Cap and Base.

Three feet, six inches high over all.



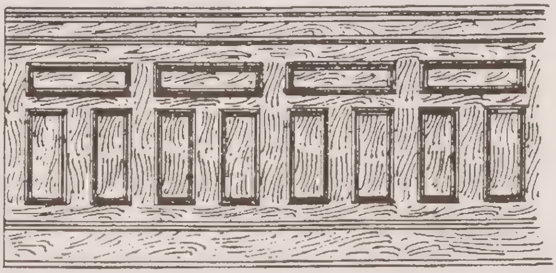
1180

Plain Sawed Oak per running foot, $1.50
Quarter " " " 1.75



1181

Plain Sawed Oak .... per running foot, $2.00
Quarter " " .... " " 2.25



1182

Plain Sawed Oak .... per running foot, $2.00
Quarter " " .... " " 2.25

Subject to Discount.

Panelled wainscotting taken from a 1905 supply catalogue, reproduced in The Victorian Design Book.

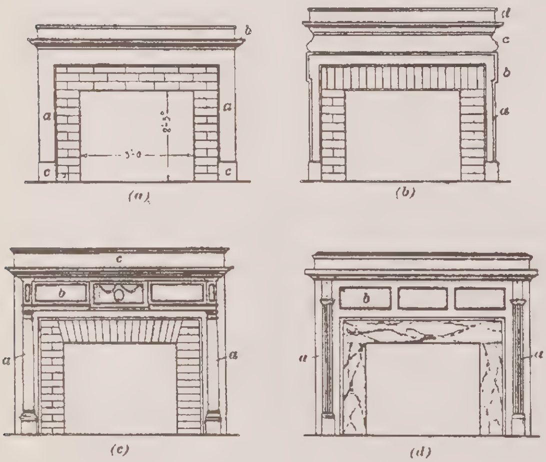
3.3 CHIMNEY PIECES

Chimney pieces or mantels are the applied decoration around a fireplace. Although they are sometimes constructed in stone or other materials, chimney pieces constructed in wood are joiners' art.

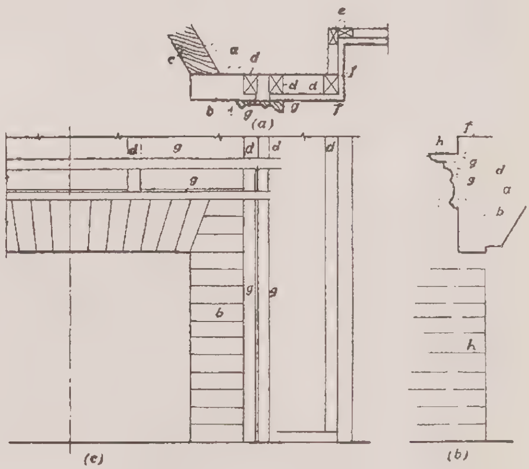
Traditionally the same joiner who made and installed the applied woodwork in the room would make and install the chimney piece using similar mouldings in a similar style.

The following section is taken from *Carpentry* (1943). Although this manual was published relatively recently, the design considerations and construction approach are similar to those of the previous two hundred years.

> Mantels may be of the simplest design or may be elaborate. The design in a. consists of a plain board *a*, such as a door or window casing. A molded shelf *b* surmounts this casing. A scribe molding must be used to scribe against the brickwork of the facing of the mantel.
>
> The mantel b. consists of a back-band trim a resting on plinth blocks, Features called Croisettes, shown at *b*, are used for ornamental effect. The frieze *c* is curved in profile and the molded shelf *d* is placed on top of the frieze.
>
> The design c. is an elaborate mantel. This mantel has two free-standing columns a, surmounted by an entablature. The frieze *b* is panelled and the central panel is decorated with composition ornament. A fascia *c* is used above the shelf.
>
> The mantel d. is formed with pilasters *a* with an entablature over them. The frieze *b* is paneled.
>
> In these designs, different styles of borders, such as brick, in various arrangements in a., b. and c. and marble in d. are shown. A scribe molding must therefore be used to close the joint between the wood mantel and the fireproof border. The molding strips must be carefully scribed against these borders.



(after Lowndes)



(after Lowndes)

Suitable grounds of furring should be placed in position to receive the mantel before the plastering is started. In a. is shown a horizontal section through the jamb of a fireplace and mantel. At *a* is the common brickwork of the chimney, at *b* a face-brick border and at *c* a firebrick lining of the fireplace. At *d* are studs and at *e* furring strips that are used to support the plastering *f*. The face of the plaster is brought out even with the face of the brick border b. Grounds g are nailed to the studs so as to receive the mantel is placed against the grounds and nailed to them.

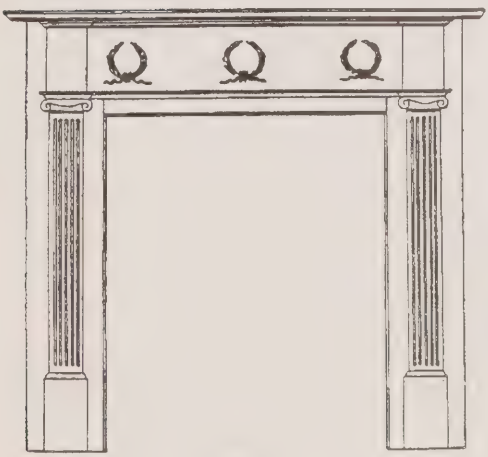
The section b. shows the chimney *a*, the face-brick border *b* and the studs *d* supporting the plastering *f*. The grounds *g* are nailed to the studs and the shelf *h* is nailed to one of them.

The mantel is planted against the grounds and nailed in position. A scribe molding *i* in a. and in b. is attached loosely to the mantel when the mantel is delivered at the building. It is removed when the mantel is being set and is afterwards scribed to the face of the brick borders and nailed in place after the mantel has been set.

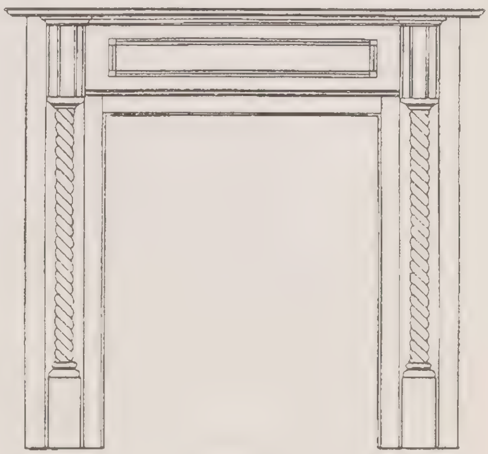
In c. are shown the studs *d* and the grounds *g* in position to take the plastering and the finished mantel. All the grounds must be plumb and true.

A simple mantel such as shown in a. may be sent to the building knocked down. It can easily be built in place in the same manner as a doorway is trimmed. The plinth blocks *c* are first nailed to the grounds. The side casings are cut square at the bottom, mitered at the top and nailed in place. The top piece of trim is mitered and nailed in place. The shelf is next nailed in place and the mantel is complete.

WOOD MANTELS.



1241.



1240 B.

In ordering give length and height of shelf and size of fire opening.
Made of pine, yellow pine or cypress, or any of the hardwoods.

WRITE FOR PRICES.

From The Victorian Design Book *reprinted from a 1903 manufacturing catalogue.*

> Mantels such as b., c. and d. are built up and shipped to the building ready to nail in place. They may be ordered from manufacturers' catalogs (Lowndes).

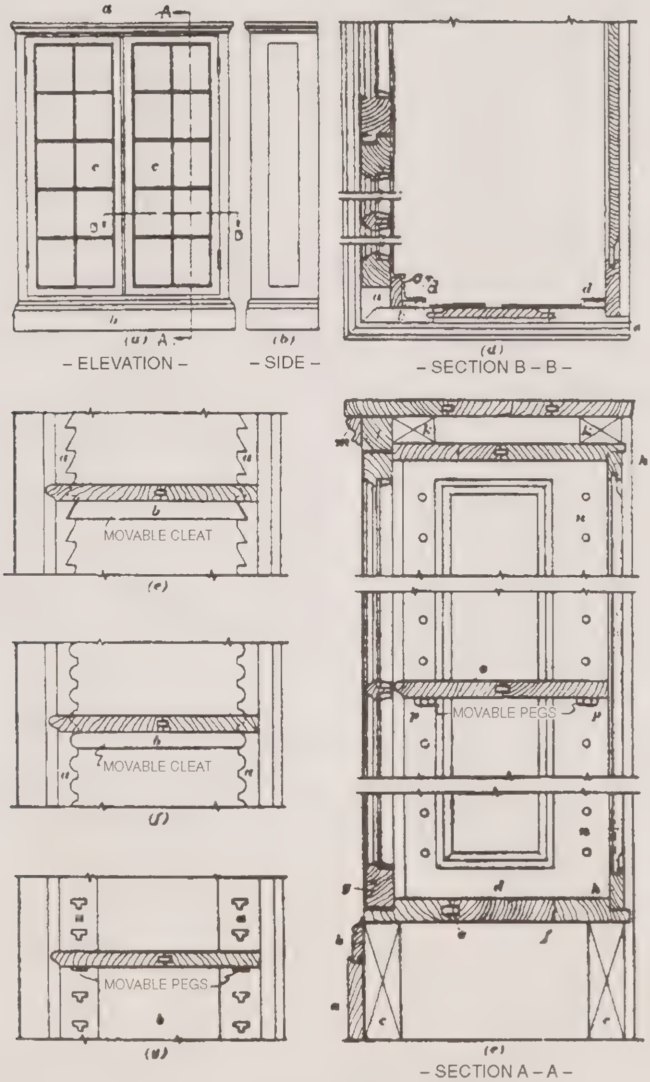
In 18th- and 19th-century kitchens the chimney piece and storage cupboards were often constructed *in situ* as one assembly. Like most types of building components, chimney pieces could be ordered factory-made by the late 19th century.

3.4 MISCELLANEOUS FITTINGS

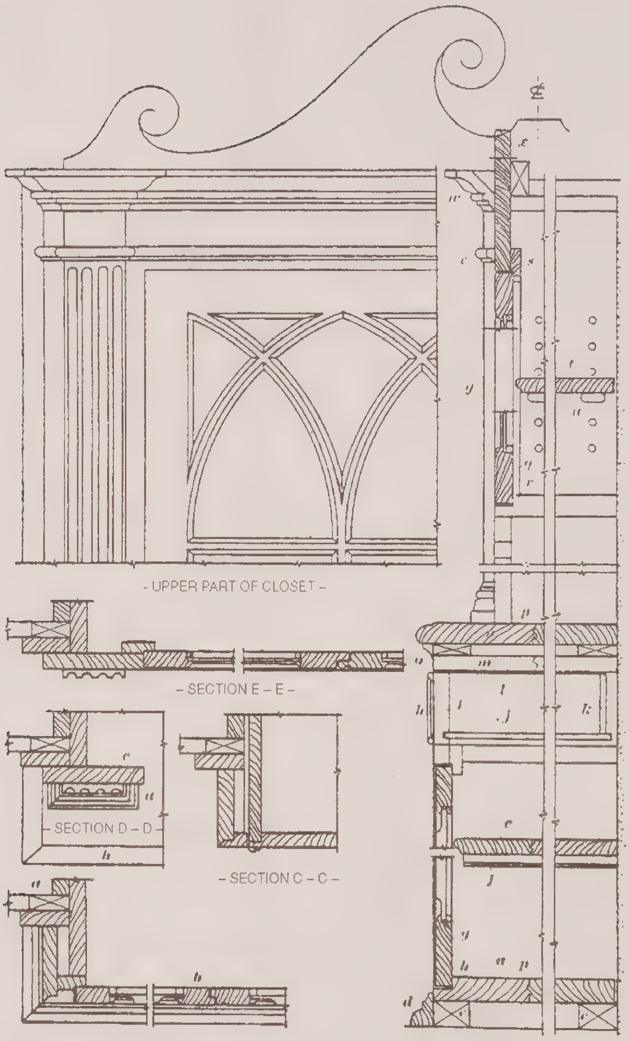
Many types of fittings were built into buildings as permanent fixtures. These included bookcases, cupboards, cabinets and window slats. These fittings were often built in the style of the day by the same joiner who made and installed the other finish woodwork.

The following selections and illustrations from *Carpentry* (1943) describe the design and construction approach taken in the first half of this century:

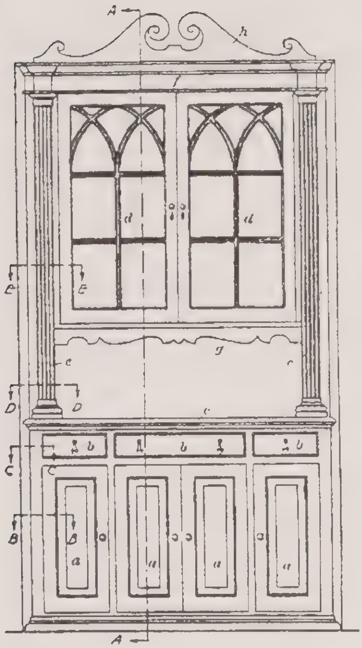
> **Bookcases** are often built into a building as permanent fittings. They may be built into recessed spaces so that the face is flush with the surfaces of the wall or they may be built against the face of the wall.
>
> In a. is shown an elevation of the front of a simple bookcase. In b. is an elevation of the end. In c. is a cross-section through the bookcase and in d. is a portion of the plan showing the end.
>
> The front elevation a. shows the cap *a*, the base *b* and the doors *c*. In the section c. many of the details of the construction are shown. The base consists of two pieces *a* and *b*. The timbers *c* support the bottom shelf *d*. This shelf may be made of one width of board or better, of two or three widths glued together, with splines *e* or with glue joints *f*. The bottom shelf is rabbeted to take the doors *g* in front and the paneled back *h* at the rear.
>
> The top of the bookcase is formed of two pieces *i* and *j*, which are formed of pieces glued together and held apart at the proper distance by the blocks *k*. The doors *g* strike against the front of *i* and the back *h* fits into a rabbet in *i*. The piece *l* runs around the top of the case and receives the molding *m*, which runs around the three sides of the case.
>
> The doors *g* are ordinary glazed doors, the glass of which is held in place by wooden stops. The sides of the case *n*. The shelves are adjustable, that is, they can be raised or lowered as desired and can be supported in any position by devices consisting of cast-iron pins that fit into holes bored in the sides of the case 1 inch apart in a vertical direction. Four pins are inserted into the four holes at the same level and the shelf is laid on them.
>
> The plan d. shows a method of joining the front of the case *a* to the paneled side *b*. It also shows a strip *c* which is secured to *a* and forms a rabbet to take the doors. The strips d. are for the purpose of supporting the shelves shown in c. and f.
>
> The paneled side in d. is rabbeted as at *c* to take the paneled back. It extends beyond the back so that the thin edge can be scribed against a plaster wall or wood paneling with which the wall may be finished.
>
> **China closets or dressers** are built in dining rooms to contain the chinaware, dishes, silver, etc. that are used in the dining room. China closets generally have one face enclosed by glass doors so that the more attractive pieces of china, glassware, etc. can be seen. This gives the china closet a decorative value. This fixture, being in the dining room, should be of a tasteful design and should harmonize with the trim of the doors and windows.
>
> An example of a stock design for a china closet is given. In this design a series of paneled doors is shown at *a*. These doors enclose closets in which chinaware and table linen may be stored. Above the doors are drawers *b* for the silver. A counter shelf *c* forms the top of this part of the closet and reaches to the back of the closet forming a deep shelf. Above this space is a closet enclosed in glazed doors *d*. These doors have an ornamental pattern formed by the curved muntins. Two fluted pilasters *e* and a molded cornice *f* frame this upper closet. Scroll saw work *g* and *h* add a pleasing finish to the whole. The design shows the front of the closet only.



Bookcase Construction



Construction of the China Closet



Stock Design for a China Closet
Inner room opening showing use of the Doric order in design a. and the composite order in design b.

Kitchen and Pantry Cabinets. An example of casework is shown, which represents a kitchen or pantry dresser. In a. is shown a front elevation, in b. a side elevation, in c. a plan of the upper section of the dresser, in d. a plan of the lower section and in e. a section through the lower part of the dresser on the line D-D. Three more sections are shown through the dresser taken on the lines A-A, B-B and C-C.

The countershelves, tops, bottoms, shelves, molding boards and sides are all glued up of two or more narrow pieces, as is customary where these features are more than 8 or 10 inches in width. They are then dressed to the proper thickness and sanded.

The sash doors and panel doors are made as described under the construction of sash and doors.

The sides and back of the flour bin are glued up of two or more pieces and are cut to the pattern shown in section B-B.

The drawers are made with the fronts mortised with the sides as shown in a.. They may be made with lips *a* in b. that project around three sides of the drawer, in which case the drawer will project beyond the faces of the stiles. The bottom *c* of the drawer is shown as being constructed of three plies of veneer. The bottom is let into the front and sides of the drawer as at *d* in c.. The bottom of the drawer passes under the back. A drawer should not fit tightly against the front of the cleats. It should have enough play to move easily and smoothly.

Inner Room Openings. It is sometimes desirable to have two rooms open into each other and yet have a partial separation. In such cases colonnades or inner-room openings are used to partially separate the rooms. A simple and dignified treatment which consists of pilasters fitted against the wall and free standing columns as shown at *b*. A cornice is carried across the ceiling and the opening is thus neatly framed.

… if they are more than 5 or 6 inches in diameter, then they are built up of staves and are joined together. In this figure two types of flutings are shown. These columns are made at a wood-working mill and are placed and nailed in position.

Windowseats. A detail drawing is shown of a window seat such as would be placed in a bay window. This seat may be made any length according to the width of the bay. It frequently serves to conceal a radiator which is placed inside the body of the seat, the heat entering the room through the grille or register. The seat consists of a framework. A wooden back may be installed or omitted as desired.

The box is lined throughout with sheet asbestos, which protects the woodwork from the heat. The seat proper is hinged and can be raised when it is necessary to turn the steam or hot water off or on or it is possible to have the valve project through the face of the seat so that the heat can be turned off or on without raising the seat. The back of the seat is paneled and the sides of the seat may also be paneled if desired.

The construction of this seat is a simple matter of stiles, rails and panels such as are used in door construction.

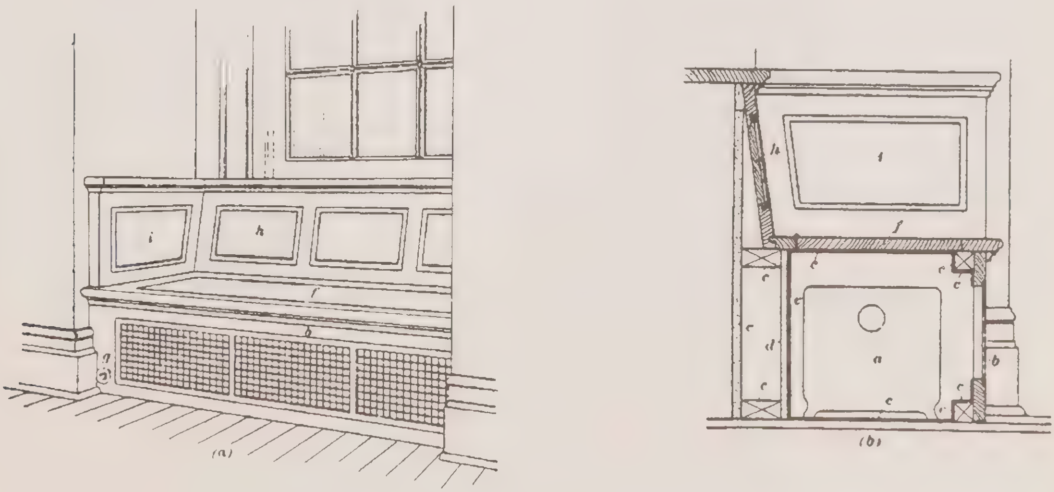
(b)
(a)
A
B
C
– SECTION B – B –
– SECTION A – A –
– SECTION C – C –
SHELVES
(c)
– UPPER PART –
SHELF
BIN
DRAWERS
D
(d)
– LOWER PART –
(c)
– SECTION D – D –
Depth of Drawer
Width of Drawer
Width of Drawer Opening
Height of Drawer
(a)
(c)
(b)

Casework

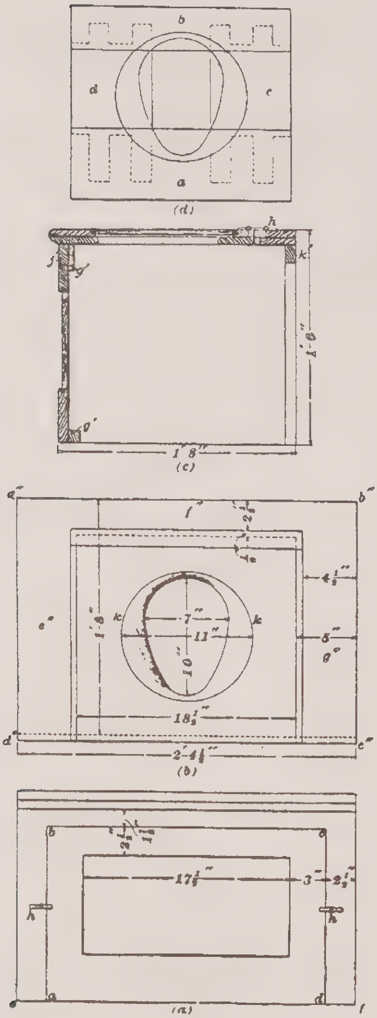
> As with all stylistic aspects of the joiner's art, innumerable regional variations were found. By the turn of the twentieth century, most fittings began to be mass-produced (Lowndes).

Early *water closets* fell into the joiner's realm. The following section from *Masonry, Carpentry, Joinery: The Art of Architecture, Engineering and Construction in 1899* described the construction of fittings for a toilet fixture:

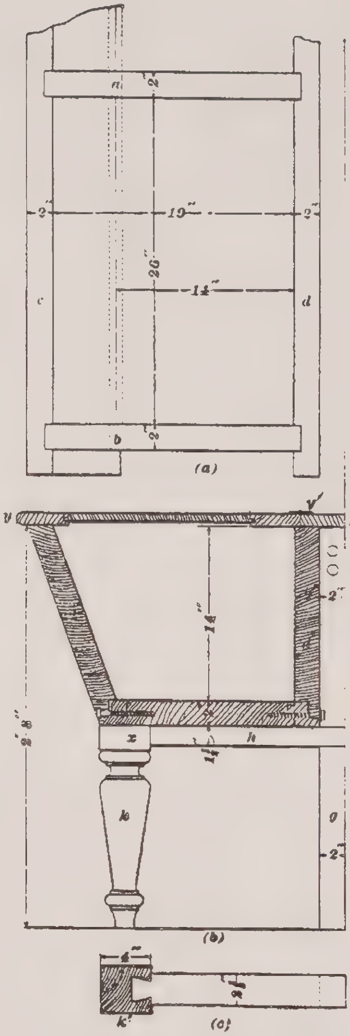
> Though the location of the fixtures and the arrangement of the pipes in the bathroom are usually considered only in connection with the plumbers' work, the finish of these details and the general interior treatment of the room are entirely in the hands of the joiner.
>
> [Shown is] ...the front elevation of the enclosure around the water-closet seat, when such an enclosure is required by the character of the plumbing. The paneled front *a b c d*,... on the back of which are provided the stops, shown at *g'*, in the section (c) to prevent the panel front from falling inwards, while the two thumb buttons *h*,... hold it securely in place, but at the same time permit of the front being readily removed to examine the plumbing fixtures.
>
> • • • •
>
> Washtubs are fixtures which the joiner is frequently called upon to build. ...At (a) is shown a plan of one of these tubs, at (b) a vertical section through the tub and at (c) the plan of the cross-piece under the tub and its joint with the turned leg, as seen at *x* in the vertical section. These fixed tubs are usually built either in a kitchen or laundry and consist of from two to four divisions. At (a) is shown the end tub of a set.
>
> • • • •
>
> **Butler's Pantry** – There is no part of a private residence where the joiner is called upon to do so much work in a small space as in the butler's pantry. The pantry must contain a long table for the reception of the dishes, both before and after their service in the dining room; and a sink, well lighted from an adjacent window must be provided, in which to wash them, while a dresser opposite or over the long serving table will receive the dishes after they have been washed.
>
> [Shown is a] plan of a butler's pantry such as might exist in any private city house, the details of which would be applicable to any other residence, either city



Window Seat Construction (after Lowndes)



Front Elevation of Water-closet Seat Enclosure

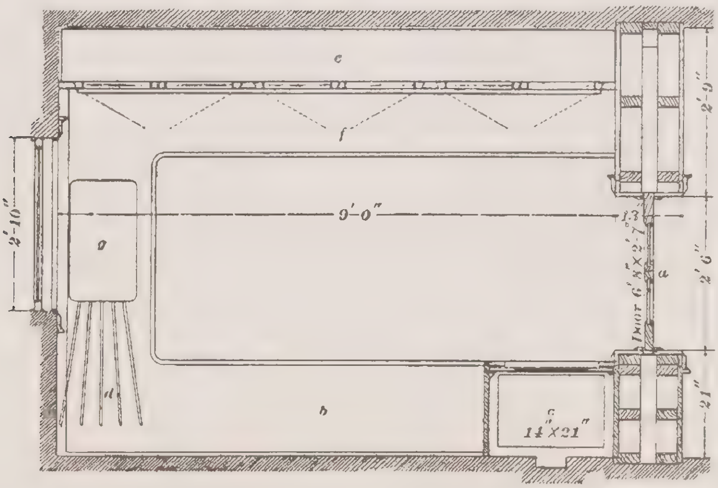


Washtub

or suburban. The entrance *a* is provided with a sliding door, for economy of space. On the left at *b* is the long service table 18 inches wide, where the dishes are placed or the carving is done before the food is served in the dining room. At one end of this table is the dumb waiter *c*... the dresser for the dishes, below which are closets *f* and drawers for silverware, dishes, etc., as shown more in detail in [the illustration].

There is no work in the construction of these pantry fittings that has not already been described. The glazed doors of the dresser *c'*... are constructed in the same manner as a hinged window sash. When the dresser is not over 7 feet long, it is sometimes advantageous to close the front with three glazed sashes, which are plowed with a groove in the top and bottom rails and are arranged to slide the full length of the dresser on hard-wood or metal tracks, which are secured just far enough apart to permit the sashes to clear one another in sliding. Or they may be made in pairs and hinged as shown on the elevation. The shelves in the dresser may be fixed permanently in place and varnished on both sides, so as to prevent any dust from sticking to them or collecting around the dishes. The drawers are provided for silverware, such as forks, knives, spoons, etc. and shelves in the closets underneath for linen and larger pieces of tableware, which cannot conveniently be put in the upper part.

The glazed closets *c'* are placed about 18 inches above the top of the linen closets *f*, thus leaving a long narrow sideboard between, the wall side of which is paneled as shown at *c'* with plain, flat, unmolded panels. ...The glazed closet is secured against the wall, but is supported by means of metal or wooden brackets,... placed one at each end of the closet and one under each of the mullions (International Library of Technology, pp. 10:93-99).



Plan of Butler's Pantry

4.0 BIBLIOGRAPHY

Anscombe, I., and C. Gere. 1978. *Arts and Crafts in Britain and America*. London.

Association for Preservation Technology, The. 1981. *The Builder's Dictionary*. Reprint of 1734 edition. Ottawa.

Benjamin, Asher. 1827. *The American Builder's Companion*. Reprinted 1969. New York.

Fleming, J., H. Honour and N. Pevsner. 1982. *The Penguin Dictionary of Architecture*. Harmondsworth.

Graham, F.D., and T.J. Emery. 1928. *Audel's Carpenters and Builders Guide No. 4*. New York.

Harmon, C.B. 1929. *Millwork*. Scranton, PA.

International Library of Technology. 1899. *Masonry, Carpentry, Joinery: the Art of Architecture, Engineering and Construction in 1899*. International Textbook Co., Scranton, PA. Reprinted 1980 Chicago.

Jones, Bernard E., ed. 1910. *The Practical Woodworker*. Reprinted 1983 Berkeley, CA.

Lee Valley Tools. 1984. *The Victorian Design Book*. Originally published in 1903. Reprinted Ottawa.

Lowndes, W.E. 1943. *Carpentry*. International Textbook Co., Scranton, PA.

MacRae, Marion, and Anthony Adamson. 1963. *The Ancestral Roof: Domestic Architecture of Upper Canada*. Clarke, Irwin & Co.,Toronto.

__________. 1975. *Hallowed Walls: Church Architecture of Upper Canada*. Toronto.

Miner, R.G., ed. n.d. *Colonial Design Book*. Arno Press.

West, Trudy. 1980. *The Timber-Frame House in England*. London.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

8.4

PERIOD JOINERY

STAIR BUILDING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

This article is concerned with the historical technology of wooden stair building.

The text includes numerous quotations from period handbooks, in order to demonstrate how stairs were constructed and to aid in their restoration. It is not intended to be a history of decorative style and therefore does not address the evolution of design.

Stairs provide a means of getting from one level to another – inside or outside a building. In their most primitive form stairs are nothing more than ladders, while in formal buildings the staircase is often a significant architectural feature.

In Canada many factors have affected the forms which staircases have taken. In pioneering eras staircases tended to be simple, functional and frequently hidden. As social and economic climates improved, stairs were built in the style of the day as architectural features. Construction details changed as a result of technological forces. Cultural and regional influences also played a role in the design and detailing of staircases.

The nature of wood staircase design has changed little in the last three centuries. What has changed is the way in which the materials are prepared and connected.

2.0 STAIR BUILDING TERMINOLOGY

2.1 DEFINITION OF PARTS

The following definitions of staircase components terminology are taken from *Carpentry: Book III: Stair Building*:

> A **stair** is a single **step** in a series. By the term **stairs** is meant a complete series of steps that are used as a means of access from the floors of a building. A **flight of stairs** is an uninterrupted series of steps between floors or landings. The complete stairs may consist of two or more flights of stairs.
>
> Shown are the stairs between two floors. Single stairs or steps are shown at *p, c* and *a*. The stairs consist of three single flights as marked on the plan.

A **landing** is shown at *d*.

A **stairway**, or **staircase**, is the part of a building that contains the stairs, as shown at *bfgo*. The terms stairway and staircase are often used to define the stairs.

Each stair, or step, consists of a **tread** and a **riser**. The tread is the horizontal part of the step on which the foot is placed when a person is ascending or descending the stairs. The treads are marked *p, c,* and *a*. The riser is the vertical part of the step under the front edge of the tread, shown at *d*.

The **run** of a step is the horizontal distance between the faces of two adjacent risers. The **rise** of a step is the vertical distance between the top surfaces of two adjacent treads. The terms tread and riser are often used to express the run and rise of a step. Thus, a stair is said to have a 10-inch tread and a 7-$^1/_2$-inch riser, which means that the run of the step is 10 inches, and the rise of the step is 7-$^1/_2$ inches.

A **nosing** is the edge of the step that projects in front of the face of the riser. It generally has the form of a half-round. A cove molding is generally placed against the face of the riser and under the nosing.

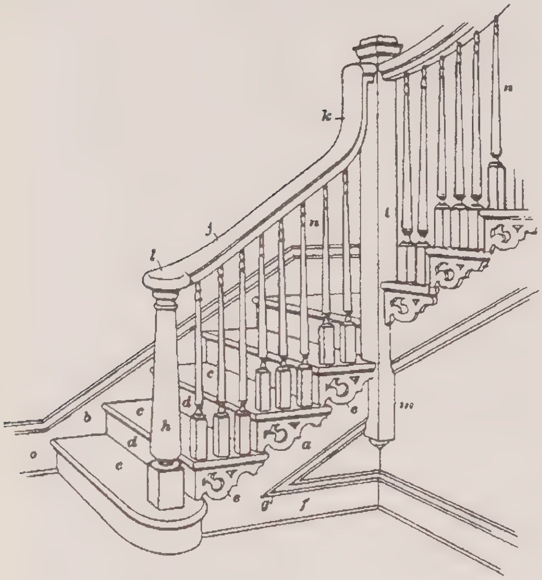
Fliers are treads that are of uniform widths throughout their lengths.

Winders are treads that are wider at one end than at the other. Winders are used where steps are carried around angles, circles, or ellipses.

Dancing steps, dancing winders, or **balanced steps** are used in stairs that are curved in plan. They radiate, in plan, from different centers, instead of from the same center, as in circular stairs.

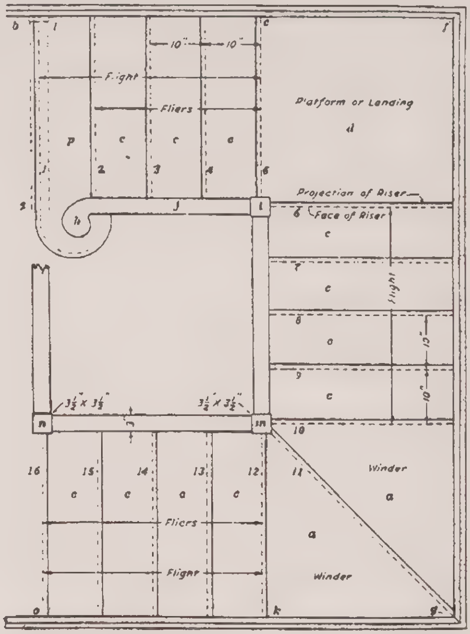
A **bull-nose step** is one that is finished with a semicircular or rounded end.

A **swelled** or **curved step** is one that has an edge. Swelled steps are generally used as the beginning or bottom steps in a flight.



Partial View of Stairs

risers: d
treads: c
fliers: c
strings, stringers: a, b
wall stringer: b
mitred baseboard:
stringer and mouldings: o
face stringer: a
outside stringer: a
newel, newel post: h
angle newel: i
drop: m
baluster: n
handrail: j
ramp: k



Plan of Stairs Between Two Floors

single stairs or steps: p, c, a
landing: d
platform: d
stairway or staircase: bfgo
treads: p, c, a
fliers: c
winders: a
quarter-space landing: d
strings or stringers: b
newel, newel post: h
angle newel: i
half-newel: l
handrail: j

(after Lowndes)

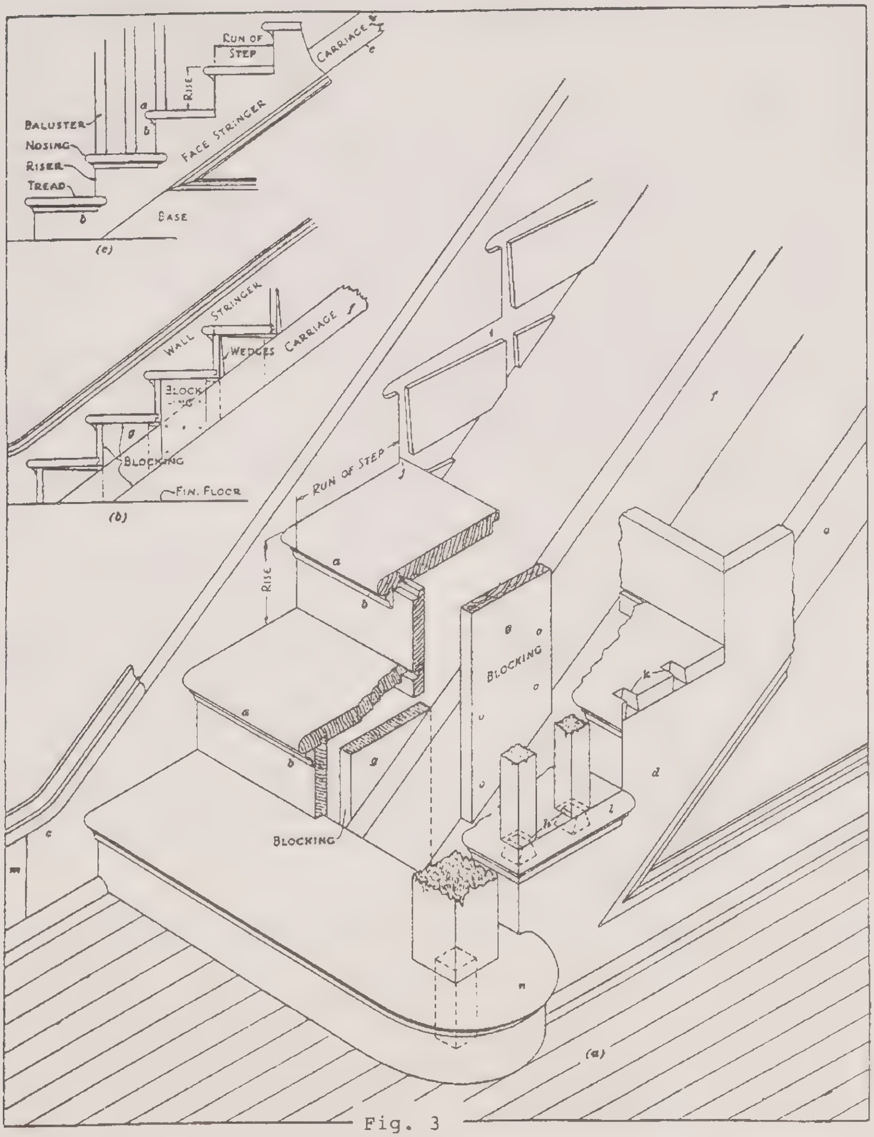


Fig. 3

Profile of Steps

nosing: a	*eased stringer: c (a)*
covemoulding: b	*face stringer: d*
bullnose step: first step	*outside stringer: d*
wall stringer: i in (a)	

(after Lowndes)

A **curtail step** is one finished to correspond with a spiral handrail. It is generally used as the first step in the stairs.

A **platform**, or **landing**, is a level space that occurs between floor levels. If the landing is formed by the stairs turning at an angle of 90 degrees, or at a right angle, it is called a **quarter-space landing**. If the stairs turn at an angle of 180 degrees, the landing is called a **half-space landing**. The floors where they meet the stairs are sometimes called landings.

The **pitch** of a flight of stairs is the angle of slope, or inclination, that it makes with reference to the floor surface, the inclination being measured along the tops of the nosings, or along the main lines of the stringer.

Strings or **stringers** are the finished inclined boards that receive the ends of the steps.

A **wall stringer** is one that is attached to the wall and receives the ends of the steps at the wall. The wall stringer is generally grooved to receive the ends of the steps. The steps when let into the grooves are said to be **housed** into the stringer, and the wall stringer in such cases is often referred to as a housed stringer.

The wall stringer is generally continuous with the baseboard. The faces should therefore be flush. The moldings on top of the baseboard should be carried up on the stringer. The stringer is **eased** or curved to meet the baseboard, while the stringer and the baseboard, as well as the moldings, are mitred together.

A **face stringer** is the stringer opposite the wall stringer. It is also called the **outside stringer**.

A face stringer may be cut so as to show the profiles of the steps, in which case it is called an **open stringer, cut stringer** or **cut-and-mitred stringer**, or cut to receive the ends of the treads and risers, when it is called a **housed, closed**, or **close stringer**.

A **newel**, or **newel post**, is an ornamental post that is used at the beginning of the stairs or at an angle where the stairs turn, to support the handrail. An angle newel is one that is placed where the stairs change direction.

A **box newel** is one that is formed of four or more paneled sides and is hollow like a box.

A **half-newel** is, as the name implies, a part or half of a newel that is used against a wall to receive the hand rail.

A **drop** is an ornamental end on the lower end of a newel.

A **newel cap** is an ornamental or molded cap on top of a newel.

Balusters are small ornamental posts that support the handrail. They are from 1 to 3 inches thick and are generally turned. They may also be carved.

Pin balusters are plain balusters that are square or round in section and taper off toward the top.

Stick balusters are square in cross-section and of uniform thickness throughout their length.

A **handrail** is a strip of wood, generally molded, that is set on top of the balusters and between the newels, and affords support and protection to persons using the stairs.

An **easement** is a curved portion of a handrail.

A **ramp** is a curved bend in a handrail which is used to carry the handrail up to a higher level on the newel.

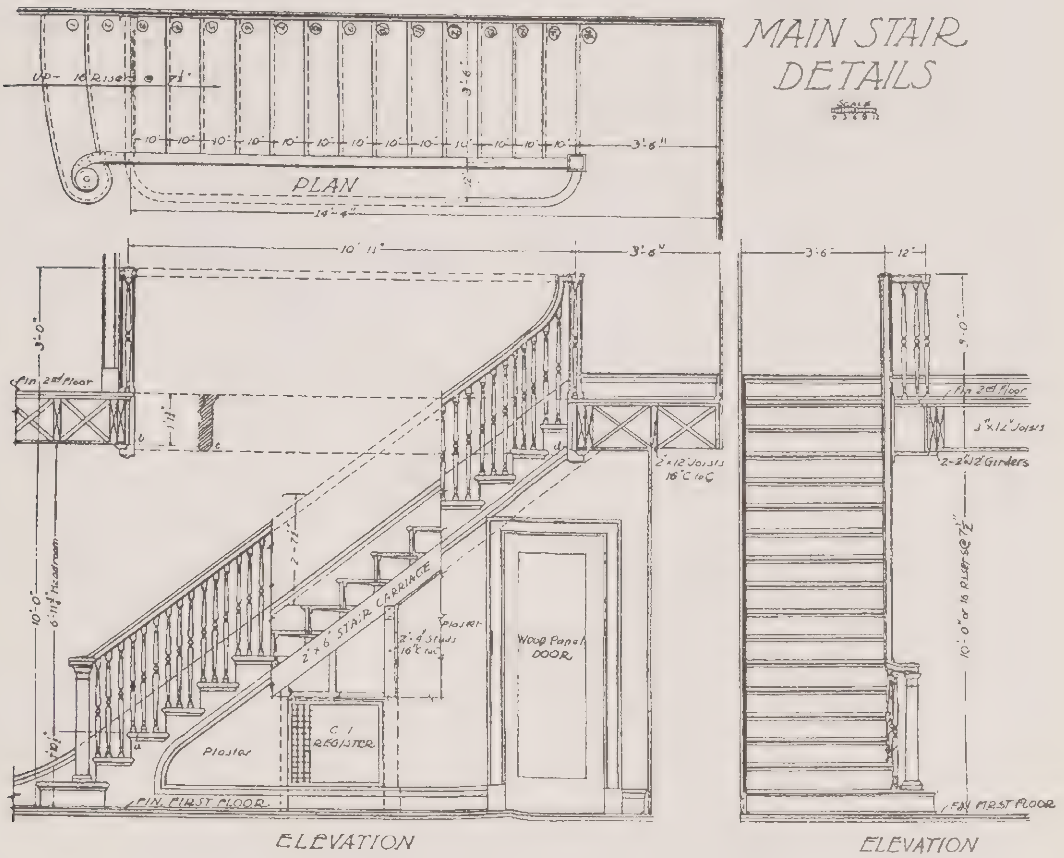
(Lowndes)

3.0 DESIGN OF STAIRS

The prime considerations in staircase designs were not much different in the early 18th century than in the early 20th century. In *The Builder's Dictionary, Vol. II*, first published in London, England, in 1734, the rules affecting staircase design were described as follows:

1. That it have a full free light to prevent accidents of slipping, falling, etc.

2. That the space over-head be large and airy... because a person spends much breath in mounting.



Simple Stairs

> 3. That the halfpaces or landing places be conveniently distributed for reposing by the Way.
>
> 4. That to avoid rencounters, and also to gratify the eye of the beholder, the stair case be not too narrow; but this last is to be regulated by the quality of the building; and that in royal buildings, the principal ascent be at least 10 foot. For a little stair case in a great house and a great one in a little house, are both equally ridiculous.
>
> 5. That great care be taken in placing the stair case, so that the Stairs may be distributed without prejudice to the rest of the building, there being much nicety required in making this choice – (*The Builder's Dictionary, Vol. II,* pp. 52-53).

Two hundred years later in *Carpentry*, the design considerations were quite similar although building codes had begun to affect design:

> In studying the plan and treatment of stairs, the architect should consider their adaptability for the building in which they are to be placed, their location, the weight likely to come on them, the width of stairs necessary to accommodate probable travel, and the ease and comfort with which they can be used.
>
> The most important consideration in designing stairs is to arrange them so as to afford the greatest ease of communication between the stories that they connect. Proper head room should be provided so that any person walking up or down the stairs will have several inches of clear space above his head at all points.
>
> The width of the stairs has much to do with their usefullness. In private houses, the width should never be less than 2 feet 8 inches, and in public buildings never less than 4 feet 6 inches. The width of the stairs as well as the number of stairs provided should be determined by the number of people using them at one time. In buildings, such as factories, churches, auditoriums, and schools, where large numbers of people congregate, the number of stairs and their size are prescribed by local and state laws, which should be referred to when such stairs are being designed.
>
> The widths and heights of the individual steps should be designed according to the conditions under which the stairs are used. In public buildings the steps should be wider and the risers lower than in private buildings. Handrails should be provided on both sides of stairs that are over 4 feet in width, and intermediate handrails should be supplied on stairs 8 feet or over in width. Long straight runs of stairs should be avoided whenever possible, as looking down on a long flight of steps suggests the danger of falling. It is always better to have the stairs between two stories interrupted, at least once in their length, by a landing (Lowndes).

3.1 TYPES OF STAIRCASES

Staircases may be classified into distinct groups and subgroups. The most common types are simple, dog-leg, open-newel, geometrical and spiral. Not all of the types are necessarily built in wood, although all are possible in wood. Spiral stairs are not treated in this manual because they are rarely built in wood. (The following discussion is adapted from *Carpentry*.)

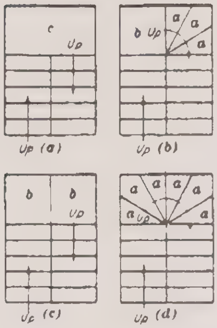
3.1.1 Simple Stairs

Simple stairs consist of a single straight flight of stairs from one floor to another without bends or turns. This type of stair is the most simple to construct.

3.1.2 Dog-leg Stairs

A *dog-leg stair* is one consisting of two parallel flights in which the face stringer of the upper flight is directly over the face stringer of the lower flight. The handrail of the lower flight strikes the under edge of the stringer of the upper flight.

Illustrated are four different arrangements of the flights in dog-leg stairs. These have quarter-space landings b., half-space landings c. and winders a. This style of stairs is used only in less sophisticated kinds of work, because the handrail cannot be arranged for comfort.

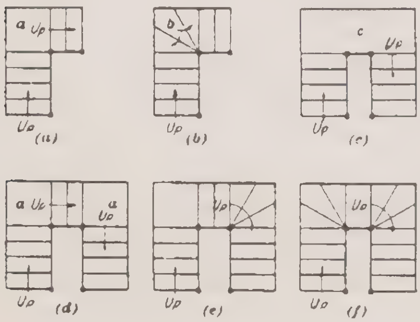


Dog-leg Stair

3.1.3 Open Newel Stairs

An *open newel stair* is one in which newels are placed at the angles of the stairs.

This form of stair is a very serviceable one and lends itself to a great variety of arrangements. In *(a)* there are two flights with a quarter-space landing between. In *(b)* winders *b* are used in place of the landing. The design in *(c)* shows two flights and a half-space landing *c*. Design *(d)* shows two longer flights and a short flight between two quarter-space landings *a*. In *(c)* there are two flights with a quarter-space landing between. Winders are used in this design. In the design *(f)* there is a narrow landing and a number of winders.



Open Newel Stair

Further diagrams of more elaborate designs for open-newel stairs are illustrated below. In (a) two flights ascend from the floor and run to the large half-space landing (*a*) From this landing a single flight runs to the second floor. In (*b*) one flight runs from the first floor to a half-space landing and two flights from the landing to the second floor. (This layout is sometimes called an imperial staircase). In the design shown in (*c*) a single flight leads from the first floor to a landing, and two flights run from this landing to the second floor. The designs shown in (*e*) and (*f*) are unusual but they illustrate possibilities of this class of stair.

3.1.4 Geometrical Stairs

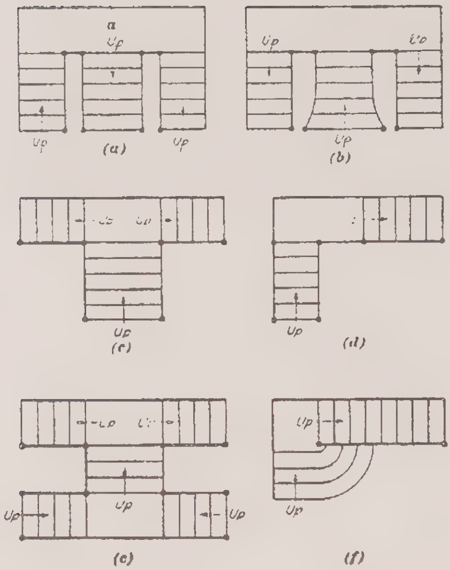
Geometrical stairs are those in which newels are not used, except at the top and bottom of the stairs and in which the stringer and handrail are curved around the bends in the stairs. The face stringer acts as a continuous beam which is supported only at the bottom and the top. Most stairs that are curved in plan are classified as geometrical stairs.

The drawings below show a number of designs for geometrical stairs, illustrating the possibilities of the design or arrangement of parts. In all these designs newels are used only at the bottom and top of the stairs, the stringers and handrails being curved in between as shown. In sketches *(a)* to *(f)* the walls are at right angles to each other, forming square corners. In *(g)* to *(l)* these corners are shown rounded. In *(m)* to *(p)* are shown elongated stairs with turns at both ends. In *(q)* are shown elliptical stairs and in *(r)* circular stairs. In *(t)* are shown fancy designs that may be used in monumental work.

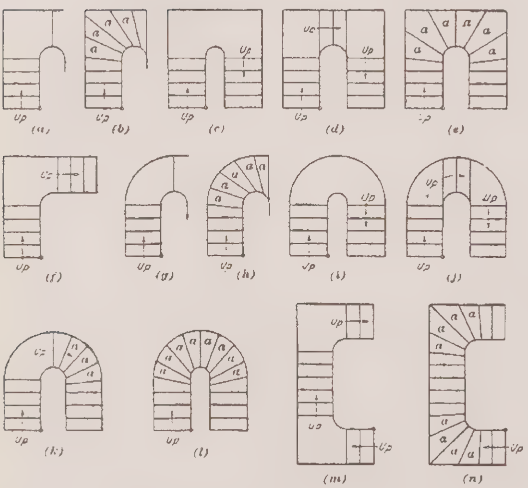
The curved parts of the stringers are called *cylinders*. The curved parts of the handrails are said to be wreathed. The curves of the stringers and the handrail are generally semi-circular in plan.

The cylinder illustrated below (p. 9) shows *a* the straight open stringer, *b* the cylinder, and *c* the fascia of the upper floor or landing *d*. It will be seen that the stringer rises as it curves, and receives the ends of the steps in the same way as does the straight stringer. At *e* is a handrail that follows the curve and rise of the stringer and at *f* a moulding under the stringer. The ends of the steps at the cylinder are narrow, as shown in the plan (*b*).

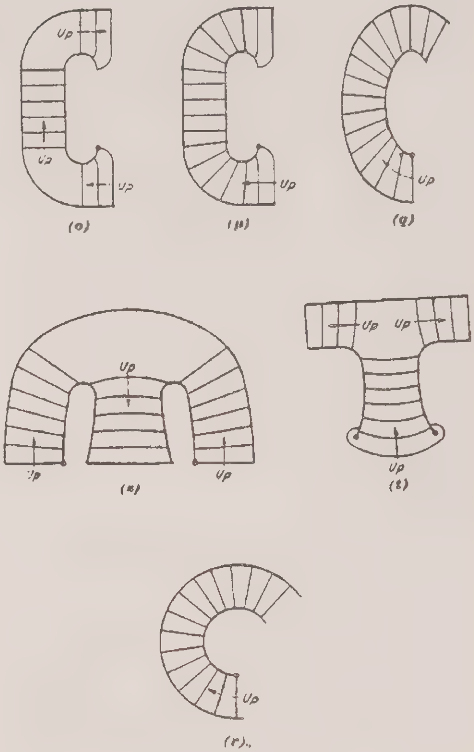
Geometric stairs were found in more sophisticated Canadian houses from the 19th century on. Because a great degree of skill was required to build a true geometric stair, compromises were often made. The job could be made easier by combining straight flights with a few winders at the top and by reserving the spiral for the bottom step and newel cage only.



Open Newel Stairs (a) to (f)



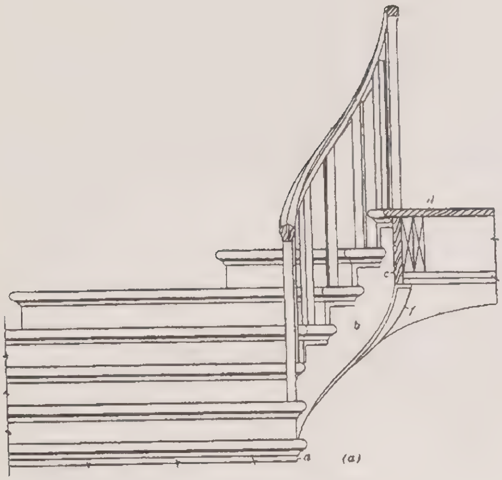
Geometrical Stairs (a) to (n)

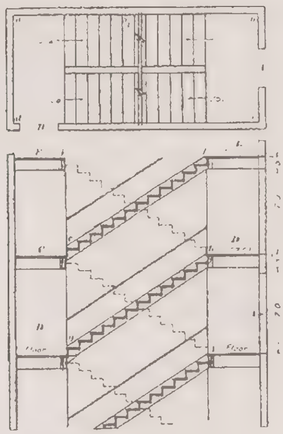


Geometrical Stairs (o) to (t)

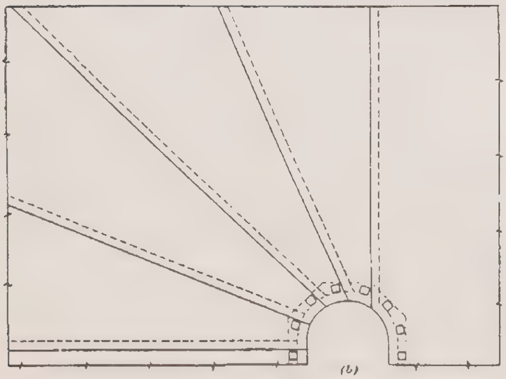
3.1.5 Double Stairs

Where the height between storeys is sufficient, two stairs can be placed in the same staircase. At each floor level two runs start up and two down as indicated by the words *Up* and *Down*. The run *ef* must be kept far enough above the run *gh* so that there will be head room between them at all points. Building the stairs in this manner economizes space, because two sets of stairs can be built in the same floor space. Stairs of this combination are most common in turn-of-the-century industrial and institutional structures.





Plan and Section of Double Stairs



Cylinders

4.0 STAIR CONSTRUCTION

4.1 LAYING OUT

The object of laying out the stair is to determine the optimum rise and run. The run will be determined not only by the rise, but also by the headroom. Once those have been fixed, the proportions of tread and riser must be determined.

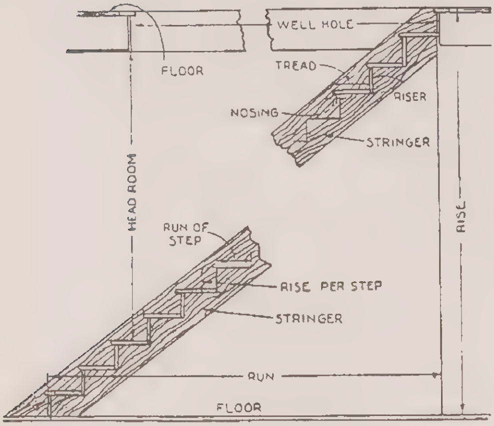
Different manuals have proposed various formulas and methods for determining the most comfortable proportions. One such formula in *Audel's Carpenters and Builders Guide* is:

$$2R + T = 24 \text{ inches}$$

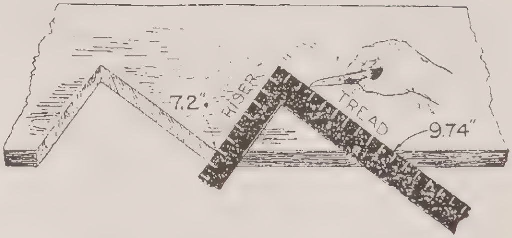
where R is the height of the riser and T is the length of the tread. A 180 mm riser and a 255 mm tread provide a comfortable step. Excessively high risers make the stairs too steep; excessively long treads make it too "slow."

4.2 CONSTRUCTING STRINGERS

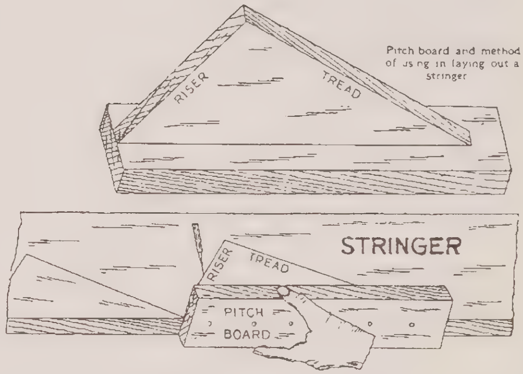
The first step in constructing stairs is to take the information from laying out and transfer it to the stringers. This is done using a square or, for very precise measurement, dividers and a pitch board.



Dimensions for Laying Out Stairs



—Application of the steel square in laying out stringers



Constructing Stringers Using Pitch Board

A *storey rod* is used to lay out the risers. It is a long strip of wood on which the height of the risers are marked, and which is used to check the stringer while they are being made. Templates are made for the treads, risers and wedges and applied to the stringers.

Stringers are constructed in a number of different ways (illustration next page). The most common are the cleated, cut, built-up and rabbetted stringers.

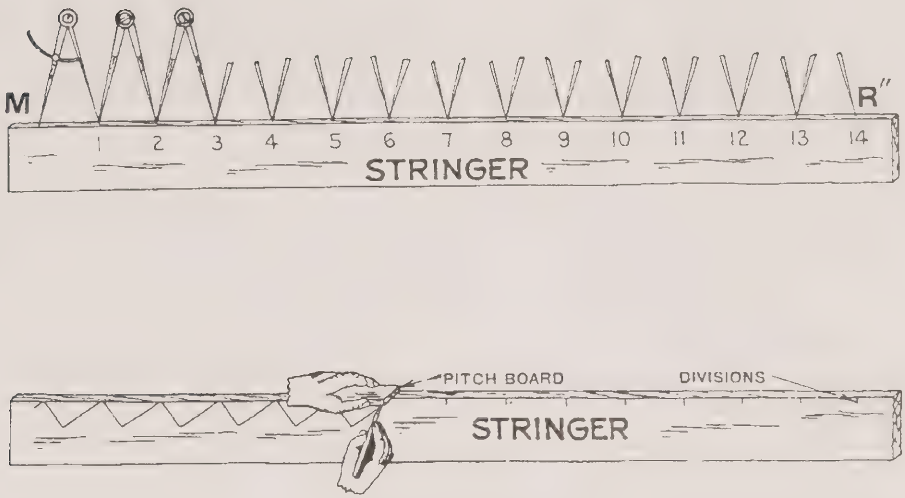
The cleated and parallel-rabbetted (or housed) stringers (marked A and D) are most commonly found in less sophisticated buildings or in stairs which provide access to basements or attics. The built-up stringer (marked C) shows the method of construction for a centre stringer when the width of stairs requires one; it is constructed by using the waste blocks out from open outside stringers. The tapered and wedged-rabbetted stringers (marked B and E) are most commonly found in well-built stairs; B and C are open stringers; A, D, and E are closed (or housed) stringers.

The following explanation of the construction of stringers is adapted from *Carpentry*:

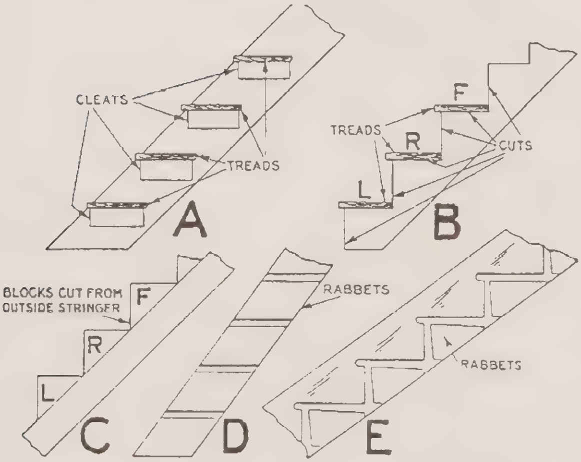
For housed wall stringers, when the patterns of the treads and risers are all laid out on the board, they are cut out of the board to the depth of 10 mm or 12 mm with a router, so that the ends of the treads and risers can be let into the stringer. The treads and risers are held firmly in place by the use of wedges which are driven in, glued and nailed.

A face stringer may be housed or open. When housed, it is laid out and housed in the same manner as a wall stringer. The steps are let into the housing and are wedged in the same manner as in the wall stringers. They are first brushed with glue and then driven in firmly, after which they are nailed with brads to the stringer.

When a face stringer is housed, it is generally surmounted by a cap which receives the balusters *a* (illustrated on p. 12) In order to take a cap of sufficient width, a panelled facing is sometimes placed outside the real stringer. Strips, or blocking, are placed between the housed stringers and the panelled facing. This construction provides a sufficient width to receive the cap and the panelling forms a satisfactory finish of the face stringer of the stair. The tread and the riser are housed into the stringer and a carriage gives support and strength to the stringer. The soffit of



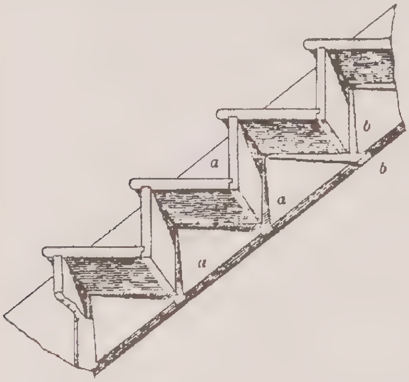
Constructing Stringers Using Dividers



Various Stringers

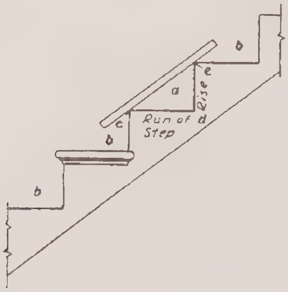
A. Cleated.
B. Cut.
C. Built up.
D. Rabbeted or housed, the sides of the rabbet being parallel.
E. Rabbeted with tapered grooves for wedges.

the stair is plastered. A moulding is nailed to the bottom of the panelling and covers the joint between the panelling and the plaster. The blocking strip is nailed to the carriage and provides nailing for the panelling and for the ground and the lath beneath.



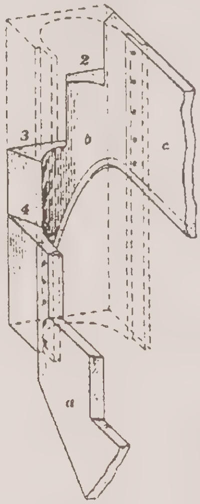
Portion of housed stringer, with treads and risers inserted.

Open stringers are laid out similarly to housed stringers, except that the pitch board *a* is applied along the top of the stringer as illustrated below and the triangles *b* are marked off. The cuts for the treads of open stringers, as at *cd,* will be horizontal cuts upon which the treads rest. The cuts for the risers *dc* are the faces of the risers, which are mitred.



Open stringers are laid out with the pitch board applied along the top of the stringer.

The construction of a cylinder, or curved part of the stringer, is seen below. Illustrated is a cylinder in position before the risers and treads are attached. The straight stringer is at *a*, the cylinder at *b*, and the fascia of the landing at *c*. The stringer *a* and the fascia *c* are rabbeted and screwed to the cylinder. The block out of which the cylinder is formed is indicated by dotted lines. The solid lines of *b* indicate the part of this block that is cut out and used. The parts shown by the dotted lines are cut off. Thus, the outer face of the stringer is carried up and around to meet the fascia *c*.



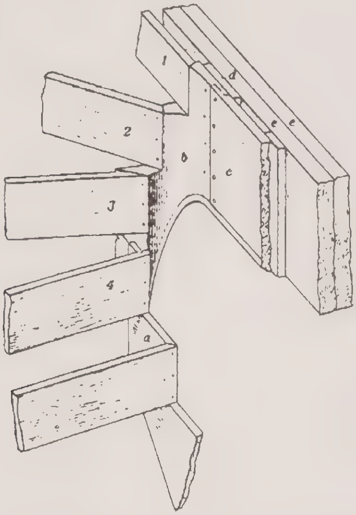
Cylinder in position before treads and risers are attached.

4.3 RISERS AND TREADS

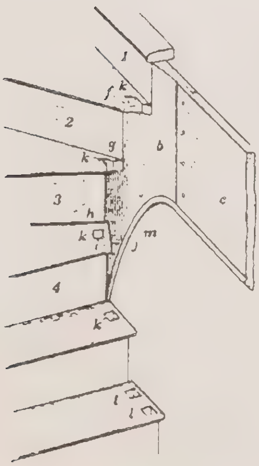
The following drawing shows a plan of the cylinder in which the open stringer is shown at *a*, the cylinder at *b*, and the fascia of the landing at *c*. In this figure are shown plans of the risers as they would be mitred and nailed to the cylinder. The cylinder is laid out and cut to take the steps as shown, and the risers 1, 2, 3, etc. are mitred and nailed to the cylinder. When the cylinder has the risers attached, the cylinder is spiked to the cleat *d*, which is fastened to the header *e*. The fascia is then halved and fitted against the cylinder and screwed in place. The open stringer will be supported on the carriage beams so that there will be no actual strain on the stringer or on the cylinder.

When the risers are all in place the treads are fitted and nailed. The ends of the winders are cut to the curve of the cylinder as shown in the next illustration at *f*, *g*, and *h*, with the exception of the nosings of the fronts of the treads which project as at *i* to take a corresponding cut *j* on the pieces of nosing that are nailed to the ends of the treads after the balusters are set in place. The

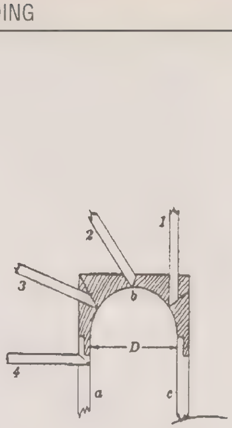
dovetail sockets *k* and *l* are also indicated. The narrow ends of the winders can take only one baluster, as at *k*, while the treads of full width can take two or more balusters as shown at *l*. The pieces of nosing must be curved, as at *m*, for the ends of the winders.



View of a Cylinder with Risers Attached



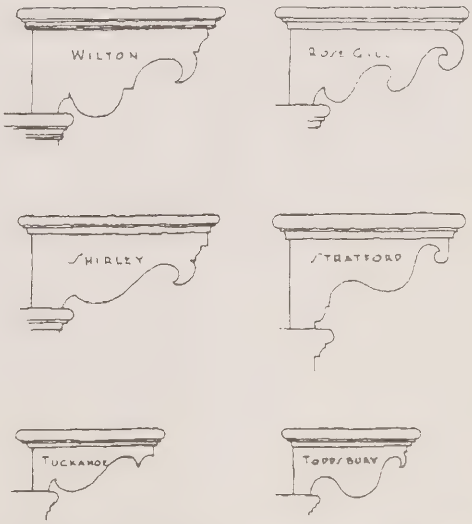
Cylinder with Risers in Place and Treads Fitted and Nailed



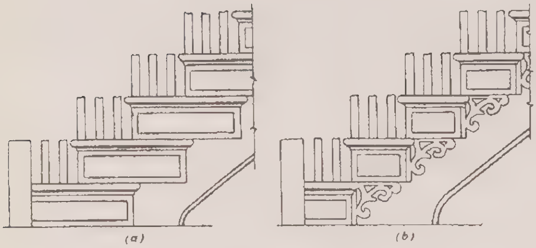
Plan of a Cylinder

4.4 BRACKETS AND PANELS

The following section adapted from *Carpentry* describes the construction and installation of bracket and panel decorations on face stringers. Late in the 19th century these decorations and all other staircase parts started to be mass-produced in urban centres. Prior to this, when stair components were handmade, great regional differences existed in stair decoration. Most occurred in brackets and panels on open stringers and also in balustrades. Very little research has been done in Canada to document regional differences.



Stair brackets shown indicate several types of regional variations.



Bracket Panels

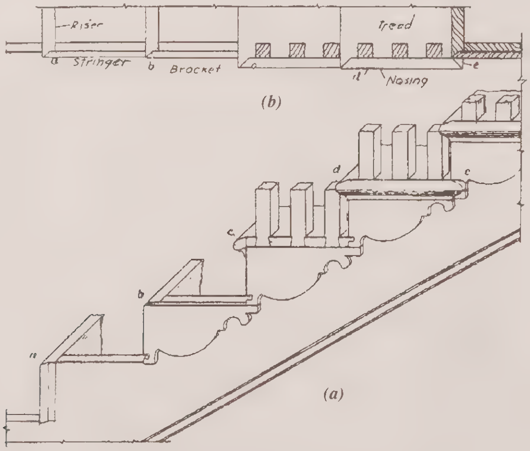
The brackets are sawed and carved out of thin pieces of wood and the edges are mitred to the ends of the risers. The above illustration *(a)* shows a long panel extending under two steps; and in *(b)*, panels with brackets beneath them are shown.

Where brackets, panels or fillets are applied to the face of the stringer, the treads and risers must be made longer than otherwise, to cover them. The illustration shows a method of fitting the riser to the brackets. At *a* in *(a)* below, the end of the riser is shown partly squared off and partly mitred. The bracket extends over the square part of the riser and mitres with the mitred part as shown at *b*. The tread is also cut longer so as to extend over the top of the bracket as indicated at *c*. The bracket must be designed so that the nosing *d* can be nailed across the end of the tread and be returned against the face of the stringer at *e*. These various steps are illustrated also in the plan *(b)*, where the letters *a*, *b*, *c*, *e*, represent the same parts as in *(a)*. This method applies also to the placing of the panels and fillets.

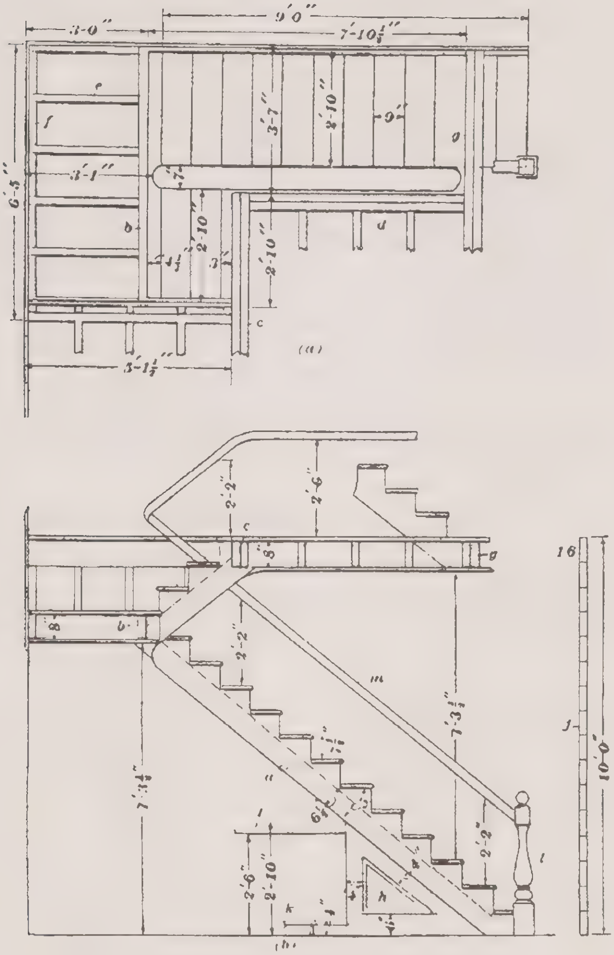
4.5 PLATFORMS AND LANDINGS

The construction of platforms and landings is described in *Carpentry*:

> *Platforms or landings* are generally framed of light timbers and are covered with matched flooring. The framing or construction of a half-space landing is illustrated, view *(a)* showing the plan of the framing and the arrangement of the risers, while view *(b)* is an elevation of the same construction. In these views the same parts are identified by the same letters.
>
> Supporting the face stringer is the carriage *a*, shown by dotted lines, the lower end resting on the floor and the upper end against the timber *b*. This timber must be placed so that the greater part of the end of the carriage rests against it, and in this case, it will be adequately supported on the partitions on the sides of the stairs. The carriage beam *c*, in this example, cantilevers over the partition, as indicated in *(a)*, and supports the header *d*, which is also supported on the carriage beams *g*. The platform is framed by extending joists *e* from *b* into the wall, where they are nailed



A Method of Fitting the Riser to the Brackets



Framing or Construction of a Half-space Landing

to the studs. Against these studs and between the joists *e*, pieces of joists *f* are nailed. When the framing, as indicated for the well and the platform is in place, the stairs can be constructed.

At *h* is shown a jib panel that is carried out to the point where it receives the handrail *i*, which encloses the run of stairs leading down to the floor below. This panel fills the triangle, which could not properly be filled with balusters and affords a neat finish to this part of the stairs. The back of the panel must be wide enough to receive not only the handrail *i* but the bottom rail *k* of the balustrade. In this illustration, the newel *l* is shown resting directly on the floor instead of on top of the step. A handrail *m* extends from the starting newel *l* to the top of the stairs.

In laying out this drawing the head room which is 2.2 m, has been carefully provided. A storey rod divided into sixteen risers is shown at *j*.

4.6 BALUSTRADES

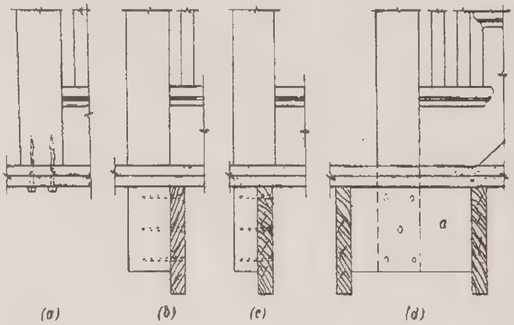
Balustrades consist of handrails supporting balusters and newels. They are used to prevent people from falling off stairs and landings and at the same time they offer support to people using the stairs.

Prior to the third quarter of the 19th century balustrade components were made by hand to suit each situation. Regional variations in style occurred. Towards the end of the 19th century, staircase components began to be mass-produced and could be ordered to suit particular situations. As a result, regional variations started to disappear.

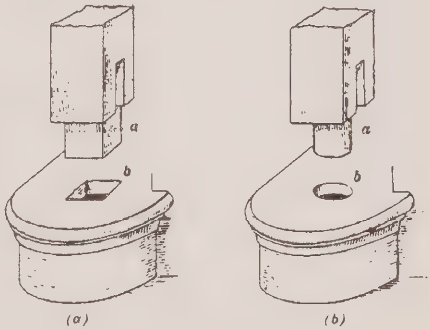
The following section is adapted from *Carpentry* and other sources:

Newels are posts that are placed at the starting points of balustrades and at the angles where the stairs change direction. They may be made of solid pieces of wood or of several strips of wood that are glued together into a solid piece and turned to the desired shape, or made in the form of panelled boxes. Starting newels may rest on the floor or on the first step. Newels may be richly carved.

Newels, when standing directly on the floor, may be secured by driving lagscrews into them through the floor, as shown at *(a)* below. Another method is to extend the end of the newel through the floor, either entirely, as in *(b)* or partly as in *(c)* and nailing the newel to the joists. If there are no joists where the newel extends through the floor, a piece of joist *a* in *d* may be nailed in between two adjacent joists and the newel end nailed to this piece.



Where the newel stands on the first step, a dowel *a* in *(a)* and *(b)* below is formed on the bottom of the newel. This dowel is let into a corresponding mortise *b* that is cut into the step. In *(a)* the dowel is shown square and in *(b)* round in section. When the dowels are fitted tightly into the mortises the newels will be held firmly in position.



Where the newel stands on the first step, a dowel is formed on the bottom of the newel.

Balusters are generally let into the ends of the steps where an open stringer is used. After a dovetail connection is made, the bottoms of the balusters are dovetailed to fit closely into the dovetail in the steps, and are forced into the cuts, after which the end nosings are nailed in place.

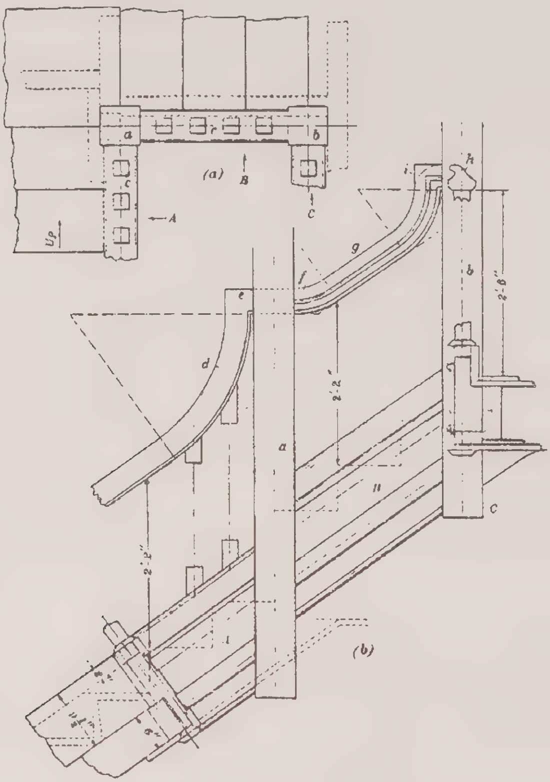
The tops of the balusters are, if round, let into holes bored into the underface of the handrail. If the tops of the balusters are square, they are cut to fit against the underside of the handrail and are nailed to it.

In newel stairs, newels are placed at the beginnings and at the turns in the stairs. The handrails extend between the newels. It frequently happens that the end of one rail strikes the newel post at a point several inches below the next higher stretch of handrail. In these cases the effect of the handrail is spoiled. It is therefore customary in the best class of stair work to bend the rails up as shown. The illustration overleaf represents a newel stair with a closed face stringer. In (a) is a plan of part of the stairway with newels at *a* and *b*. Sections through the balusters are indicated at *c*. In (b) is a developed elevation of this portion of the stair, in which the views *A* would, if straight, strike the newel *a* at a point much lower than the rail in *B*, and the rail in *C* would strike the newel *b* in (b) at a point higher than the top of the rail in *B*.

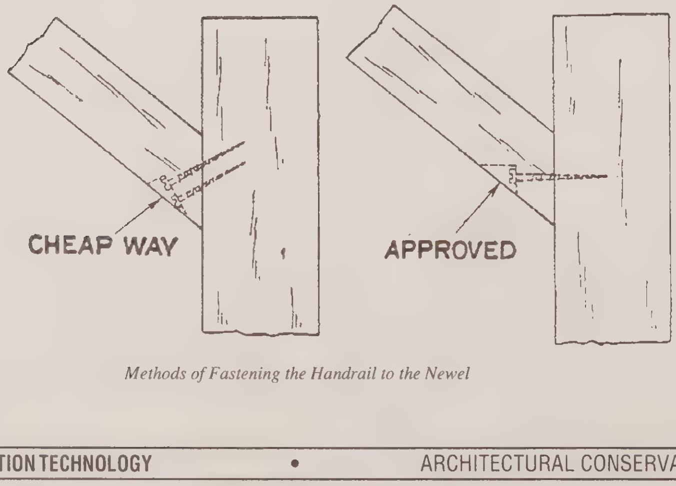
To produce a continuous smooth effect the rail *d* in (b) is bent up. This bend is cut out of a separate strip of wood and worked into shape. It is called a *ramp*. When it is curved up to the correct height it is connected with the newel by a knee, which is at right angles with the newel.

The knee is worked so as to be opposite the end of the *easement* that is formed on the end of the rail. This easement is made for the purpose of beautifying the railing. The upper end of the rail is fitted with a ramp or a knee to bring it opposite the rail.

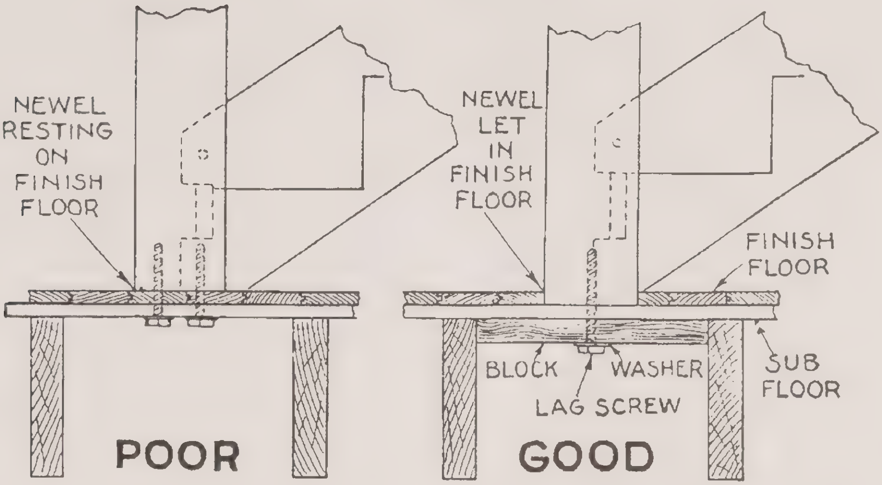
Sometimes the knee is worked into a curved shape called a *gooseneck* or a *swan neck*.



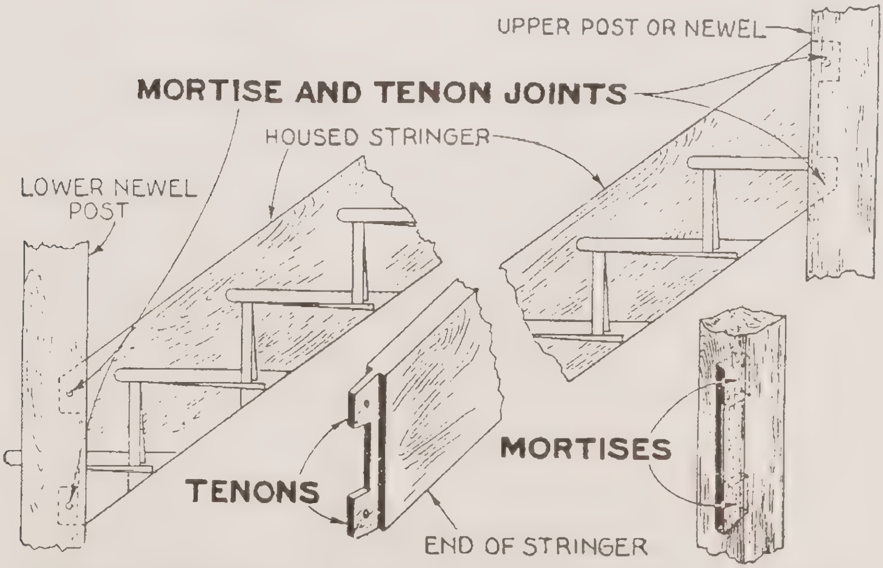
Newel Stair with a Closed Face Stringer



Methods of Fastening the Handrail to the Newel

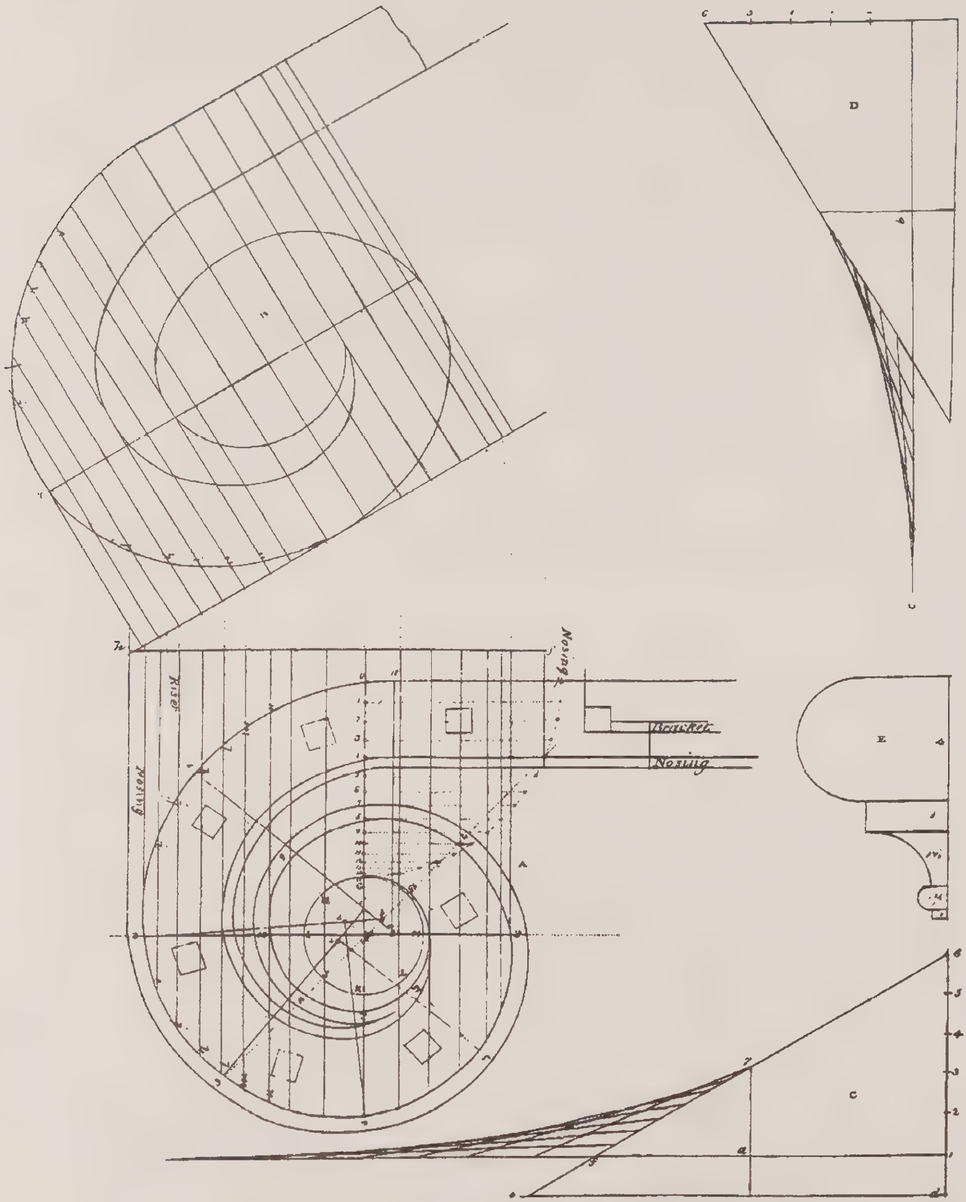


FIGS. 3,048 and 3,409.—Methods of securing newel between joists. Fig. 3,108, cheap and inferior method of placing newel on finished floor and fastening with screws or spikes; fig. 3,409, more substantial method of letting in newel through finish floor, reinforcing from below by a block and securing newel by a long lag screw. The block may run across to the joist as shown, giving extra rigidity.



FIGS 3.383 to 3 390.—Housed stringer fastened to end posts or *newels* by mortise and tenon joints and detail of the joint.

Methods of fastening housed stringers to newels and alternative methods of fastening newels to the floor with lag screws.



Detail illustrates how spiral handrails are laid out.

5.0 BIBLIOGRAPHY

Association for Preservation Technology. 1981. *The Builder's Dictionary.* Reprint of 1734 edition. Ottawa. Illustration reprinted by permission: APT. ©1981.

Benjamin, Asher. 1827. *The American Builder's Companion.* Reprinted 1969. New York.

Bullock, O.M., Jr. 1983. *The Restoration Manual.* Toronto.

Fleming, J., H. Honour and N. Pevsner. 1982. *The Penguin Dictionary of Architecture.* Harmondsworth, UK.

Graham, F.D. and T.J. Emery. 1928. *Audel's Carpenters and Builders Guide No. 4.* New York.

Harmon, C.B. 1929. *Millwork.* Scranton, PA.

Lee Valley Tools. 1984. *The Victorian Design Book.* Originally published in 1903. Reprinted Ottawa.

Lowndes, W.E. 1935. *Carpentry, Book III: Stair Building.* International Textbook Co., Scranton, PA.

MacRae, Marion, and Anthony Adamson. 1963. *The Ancestral Roof: Domestic Architecture of Upper Canada.* Clarke Irwin & Co.,Toronto.

Old House Journal, The.

Vol. 9:3.	"Wood Stair Construction."
Vol. 9:6.	"Old Stairs: Handrail Repair."
Vol. 9:7.	"Repairing Newels."
Vol. 10:2.	"Repairing a Stair at Our Old House."
Vol. 10:3.	"Repairing Stairs at Old-House Journal."
Vol. 11:2.	"Best Way to Replace a Tread."

West, Trudy. 1980. *The Timber-Frame House in England.* London.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

9.1
PERIOD ROOFING
SHINGLE ROOFING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: KEN ELDER

CONTENTS

1.0 INTRODUCTION

It is now generally accepted that the earliest use of wood shingles for roofing in North America was by the early 17th-century English and Dutch colonies on the U.S. east coast. The choice of material, while logical from the standpoint of readily available materials, is quite surprising considering that wood shingling was no longer an active tradition in the colonists' European homelands. In fact, a shortage of suitable wood had driven shingling into eclipse as early as the 16th century. By vague recollection, borrowing from other roofing methods or complete reinvention, the techniques of manufacturing and applying wood shingles were redeveloped.

Opinions are divided today over which roofing methods, if any, influenced the detailing of wood shingle roofs. The use of long shingles with purlins or shingle lath appears to have had its origins in thatching. The use of shorter shingles on close boarding would, on the other hand, seem to have been modelled on tile or slate installations. More research in this area is needed before drawing any firm conclusions.

During the 17th and 18th centuries, little change in shingle manufacture occurred. With little variation, the process remained: cutting a log into appropriate lengths, splitting the lengths into squared or quartered blocks with wedge and axe, mounting the blocks in a frow horse and splitting off shingles with frow and frow club and lastly, clamping individual shingles in a shaving horse and trimming with a draw-knife.

From 1840 to 1850, circular saws were used in most shingle manufacturing. Handsplitting survived in more remote areas into the 1890s. With mechanization came a degree of standardization, both in profile and length. In the 1890s, west coast shingle mills greatly expanded, making red cedar the dominant species for shingle manufacture.

In the late 1890s the first technical descriptions of the forerunners of present-day asphalt shingles appeared (Ritchie, p. 280). Slowly their share of the roofing market increased, mostly at the expense of wood shingling. Wood shingling never recovered its dominant position in the market.

The way wood shingle manufacture and application has developed historically has created several problems for the researcher. As an active tradition in Europe, it is too early to be described in printed works. In North America, where few 18th- and early 19th-century technical books were produced, it is almost totally ignored as a subject of interest.

Most of the information for this article is drawn from instructional texts written in 1903, 1909, 1942, trade literature of the 1960s and 1970s and a number of histories written in the last 20 years. Wherever possible, historical description is quoted to confirm a particular practice.

The materials and methods of shake and shingle roof installation today, while appearing relatively similar to their historical counterparts, are in fact altered in almost every aspect.

This article will point out these differences to assist in the proper restoration of period wood shingle roofs. When used with available iconographic, documentary and physical evidence, this article will be a useful tool in successfully repairing or reconstructing an historical wood shingle roof.

2.0 DEFINITIONS

Bands: thin metal straps used to bind bundles of shingles.

Band Sticks: strips of wood used in packing a bundle of shingles.

Board "bolt": a term used to describe a piece of wood split from a shingle length block, which could be stored in the frow horse and rived into shingles.

Bolts: a term used by the large West Coast shingle mills to describe the 48 in. - 54 in. lengths of log, already split into slabs yielding roughly 20 to 40 bolts to the cord, transported to the mills for conversion to shingles.

Compression Wood: abnormally dense wood which may form on the lower side of branches and on leaning trunks of softwood trees.

Dimension Shingles: shingles jointed to a uniform width, usually four, five or six inches.

Dressing (shaving, smoothing): an additional operation which was frequently performed on the handsplit shingle. It consisted of holding the shingle after it was split in the clutch of a shaving horse, then pulling a draw knife over the surface.

Exposure (course width, "to the weather," exposure to the weather, show, gauge): length of shingle exposed to the elements and not covered by a succeeding course.

*Frow and Frow Club (*Wigginton, p. 48)

Frow (froe): a thick-backed rigid dull bladed steel knife about fifteen inches long and three and a half inches wide, hafted at right angles upward from its blade. It is used for riving shingles, laths, staves and clapboards.

Frow Club (froe club, mallet, maul): a short maul usually cut from a single block of wood for driving the frow through the block of wood being split.

Frow Horse (board "brake", shingle horse): a tree fork about six feet long, with or without legs used to hold a block or bolt of shingle material for splitting. It sometimes also served as a seat for the workman.

Hip Roll (ridge cap, stock, ridge roll, metal roll): a preformed sheet metal product, for finishing a roof hip or ridge. A cylindrical centre section with aprons or wings extending out at each side.

Frow Club (Mercer)

Pole Laths: an expression used in *The Foxfire Book* edited by B. Wigginton to describe regularly spaced purlins or roof logs running from gable end to gable end and acting as both the roof framing and shingle lath for attaching the shingles.

Rejointing: an additional operation which was and is sometimes performed on shingles, consisting of trimming the edges parallel.

Ridge Boards (ridge saddle, ridge pieces, comb boards): two boards, tightly fitted, laid along a ridge or hip of a roof or dormer to close the joint.

Riving (splitting, cleaving): in the case of handmade shingles, the forcing apart of the wood fibre, with frow and frow club to produce shingles.

Sapwood: a tree trunk or stem has five principal concentric layers … the bark, inner bark or phloem, cambium, sapwood and heartwood. Sapwood is the layer through which the sap, water and dissolved minerals flow up the tree.

Frow Horse (Mercer)

Sarking: a Scottish expression for roof boarding or sheathing up to 19 mm (3/4 in.) thick.

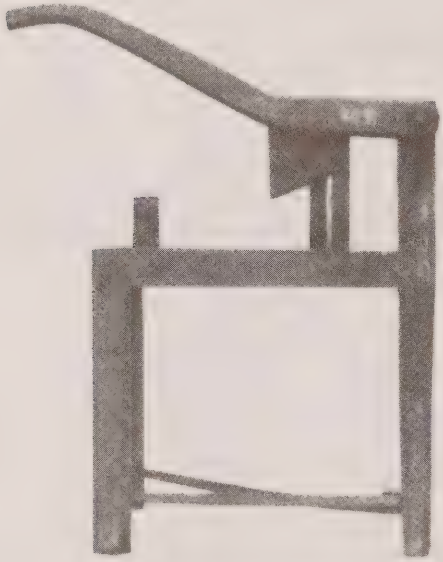
Scaler: an individual whose job it is to estimate the gross and merchantable volume of a log. His job may also include measuring other forest products in the accepted commercial unit.

Shake: a hand-split shingle, usually thicker in section [1/8 in. plus butt thickness]; the term was occasionally used in the mid-19th century and was generally used from the 1920s onward.

Shaving Horse: a foot lever-operated clamp mounted in a four legged bench or other apparatus, used to hold rived shingles for hand dressing or shaving.

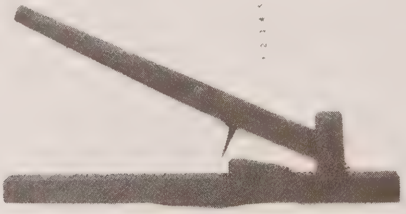
Shaving Horse (Mercer)

Shingle: a thin piece of wood having parallel sides and one end thicker than the other, used as a roof covering. The present spelling of the word dates from at least 1586.



Shingle Butter (Mercer)

Shingle Butter: a hand-operated lever with a knife blade attached which when lowered trimmed off the ends of shingles.



Shingle Punch (Mercer)

Shingle Lath, Wood Slate, Battens, Pole Rafters: plain wood strips, usually 1 x 2, 1 x 3 or 1 x 4, spaced the same as shingle exposure, and nailed across the rafters as a deck for a shake or shingle finish.

Shingle Punch: a hand-operated lever which when lowered forced a chisel shaped iron punch through a shingle making a preparatory nail hole.

Solid Sheathing (tight deck, close boarding): square-edge, matched, shiplap or other boarding, plywood or non-wood sheeting laid over the roof framing with negligible gap between individual members.

Spaced Sheathing (spread sheathing): roof boarding laid over the roof framing with a space between members not generally wider than the member itself.

Square: 100 square feet of roof surface.

Starter Course: the first course of shingles, starting from the eave. It is frequently doubled or tripled.

Tilting Fillet: a bevelled strip of wood, run along the rake, with the thinner edge inward, to give the shingles a slight tilt away from the edge of the gable.

Toe-holt: a board laid across the roof as a foot rest for the shingler and held in position by any of a number of means.

Trimming (butting, rebutting): an additional operation which was, and is still sometimes, performed on shingles. It consists of trimming off or bevelling the uneven lower end with a knife or saw to bring it to an exact right angle to the edges.

3.0 WOOD SHINGLES/SHAKES

Many types of wood were used in the past for wood shingles, particularly in the eastern areas of the country where unlimited supplies of western red cedar were not available. References to the type of wood shingles is found in a number of historical documents. In an article, "Early Roofing Materials," published in the *Bulletin of the Association for Preservation Technology,* a number of 17th- and early 18th-century documents concerning Quebec City buildings are quoted: a contract between Claude Baillif and Pierre Gacien, 1682, called for cedar shingles; a regulation made by "Le Conseil Supérieur" in 1688 prohibited oak, walnut or pine shingles; a contract between Joseph Dorion and Francis Cathcart, 1815 calls for either cedar or pine (Nelson and Dalibard, pp. 20, 21, 25). An examination of whole and fragmentary specimens of original shingles from Louisbourg, an 18th-century site, indicates Eastern white cedar, white pine and possibly balsam fir shingles were used (Cox, p. 69).

A 1909 textbook, in the International Library of Technology series, lists chestnut, hemlock, red cedar, white pine, cypress, white cedar, and California redwood as possible shingle woods. Although speaking about United States manufactured shingles, the comments on each species is valuable:

> *Chestnut shingles* are apt to curl in dry weather and when damp they swell and bulge; this continued movement gradually draws the nails and cracks the shingles.
>
> *Hemlock shingles* are more serviceable than is generally supposed, and last a long time in dry localities; but in a moist atmosphere they decay quickly.
>
> *Red-cedar shingles* are very durable, and for this reason are largely used. Because of the general straightness of grain, red-cedar shingles are not roughened so much under the sun as are other kinds, and therefore give a better weather surface.
>
> *White-pine shingles* are commonly used, because, while offering more advantages under general requirements they last longer than any but cypress, white cedar, or redwood, and do not curl and split so readily as the foregoing kinds. Their chief disadvantage is in the sawing, as the fiber roughens quite freely.
>
> *Cypress and white-cedar shingles* are the least used, and, at the same time, about the best that can be had. The wood saws fully as well as red cedar, and will not curl or split, except under excessively severe conditions; with the exception of redwood, the enduring qualities of these shingles are far superior to any other shingles known.
>
> *California redwood* makes a good durable shingle that is not as inflammable as cedar and other shingles. The wood is soft and seems to resist the tendency to rot for many years. Roofs built in such a climate as that of Boston, Massachussetts, have even outlasted those built from the best white cedar (No. 33B: *Fireproofing...*).

Tidewater red cypress and California redwood are not native to Canada and were never used extensively in this country. The comment that sawing white pine will roughen the fibre is particularly important. This may explain why most pine shingles on historic buildings are the hand-split type. It would also explain why red cedar shingles occupied such a large share of the market. The material was clearly better suited to circular sawing and mass production techniques.

A 1915 pocket book for architects and builders on the subject of wood species states:

> The best shingles are those made from cypress, cedar, redwood, white and yellow pine and spruce, in the order mentioned. Redwood, while perhaps not quite as durable as cypress, is less unflammable; sawed pine shingles are inferior to cedar and spruce shingles are not suitable for good work (Kidder, p. 1495).

The relationship between the type of wood from which shingles were cut and the durability of the roof covering has long been recognized. This is particularly clear in a chart giving "average durability of shingles in exposed situations" provided by Peter W. Plumer in his book *The Carpenters' and Builders' Guide* written in 1869:

> Rifted pine shingles from 20 to 35 years. Sawed clear from sap, from 4 to 7 years. Cedar shingles, from 12 to 18 years. Spruce shingles, from 7 to 11 years.
>
> Note: by soaking shingles in lime-water, their durability is considerably increased (Plumer, p. 16).

3.1 ASSESSING THE QUALITY OF THE STARTING TREE OR BUCKED LOG

Edwin C. Guillet, in *Pioneer Arts and Crafts*, briefly discussed the craft of splitting shingles. As far as selecting suitable timber for splitting, he offered:

> Experienced settlers quickly learned to pick sections of trees which would split fairly, for the appearance of outside knots, of the grain, and even of the limbs aided in the choice. The most suitable blocks would snap apart easily when split, without deep curves which would make holes in the shingles (Guillet, p. 6).

The comments of a hand-split cedar shingle manufacturer, when asked what kind of cedar to look for, were:

> Well, experience is always the best teacher. But in general I like the big old hollow cedar or even a

> windfall. As long as it's got a good straight grain and very few knots. Now take if a tree is growing on a sidehill and leaning bad ... the bottom side of that tree won't split good at all. That's compression wood. After you get up 20 feet or so it will do better but then you're getting into knots. You learn by experience.
>
> You can tell by the bark if the wood will split. Pick a grey bark.... By the dry checks on it or the straight creases on the bark, if all the lines and creases and checks you can find are running straight up and down you've usually got a good tree.
>
> I like to hit the tree with the blade of my axe held lengthwise, as low down and as high as I can reach. I can tell by feel how deep the wood is, or how hollow. I like to see some green limbs fairly low, it means it's got some life left in the tree. Or a stub with the top blowed off, it's usually good wood at the bottom or it would have blowed off lower down. I like to see limbs on one side, too, which means you get one good side for shakes (Mackie, p. 24).

For the manufacture of hand-split shingles on a small scale, B. Allan Mackie, an experienced log house builder, suggested:

> Select a large tree with straight grain and clear wood. A large tree is the least likely to have knots at the butt, and it is true that the better the tree, the longer the shakes that can be split from it. So, saw the wood into the lengths that can be split most readily (Mackie, p. 54).

Shingle mills today purchase logs graded by a trained scaler. In the case of red cedar, two grades are generally used for shingles, No. 2 Red Cedar Logs and No. 3 Red Cedar Logs.

3.2 HAND MANUFACTURE

To properly describe the stages in the manufacturing of wood shingles, it is necessary to divide the industry into two groups: the "cottage" or small scale industry producing a handsplit or sawn product on a limited scale and the large scale and large volume mill operation, mass producing the sawn product.

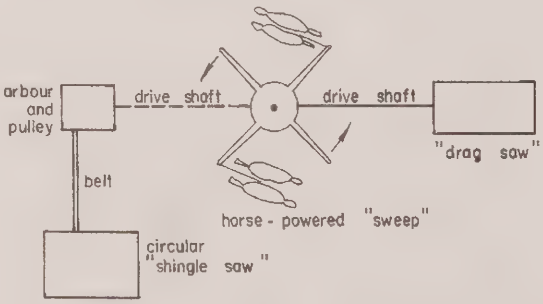
3.2.1 Preparing the Blocks

Two methods of preparing blocks for handsplitting into shingles seem to have predominated. The first consisted of cutting up the log in four to eight ft. (1219-2438 mm) lengths, splitting these with wedges and then cutting them up into blocks. The blocks would be taken out of the portions free of knots or other defects. The second method consisted of cutting up the log immediately into shingle length pieces and then splitting these into convenient blocks. At this stage the individual board "bolts" were taken to the brake for splitting with the frow club and frow.

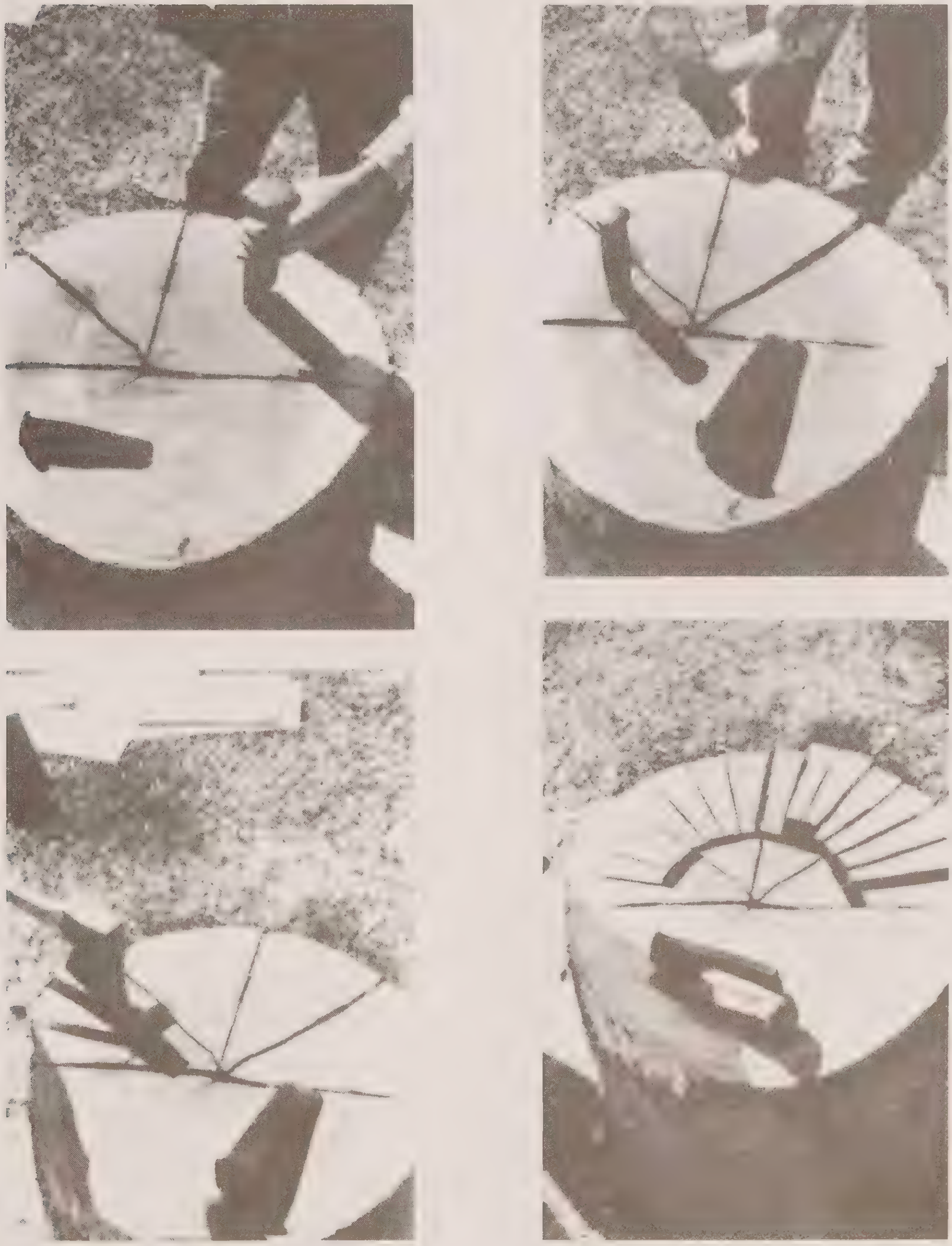
The preparation of blocks for the handsplitting of modern "shakes," while mechanized in part (i.e. the use of fork lifts and cut off saw), closely follows the method outlined above.

By mid-19th century, shingle machinery driven by horsepower or steam engine had taken over a large share of shingle manufacture. An 1858 patent machine, operating today at Upper Canada Village, is a combination "drag saw," circular "shingle saw," driveshaft and sweep powered by four horses. The drag saw converts the logs into "bolts" or blocks 16 inches to 18 inches long, depending on the length of the shingles required. A lever with a clamp holds the block which is pressed against the cutting edge of the blade. Although not observed first hand, it is suspected the clamp would accept a reasonably large diameter block, in the round.

A "shingle machine" driven by the power take-off on a steam powered traction engine was observed by the author at the Canadian Museum of Science and Technology. This machine accepted various length blocks, in the round or split.



Diagrammatic sketch showing operation of Shingle Saw at Upper Canada Village (APT 1970-57)



Preparing Blocks for Hand Splitting into Shingles (Wigginton, pp. 46-47)

(Wigginton, pp. 47-48)

3.2.2 Conversion to Shingles

No single method was used exclusively in converting the blocks to shingles. In some instances, the "bolt" or block was stood on end in a "brake" or "frow horse" for splitting, in others the bolt was stood upright on a chopping block. In certain areas of eastern Europe the block was held horizontally on a shingle bench and a planing knife was drawn towards the workman (Viires, p. 189).

Using a "brake" was a favoured method:

> The bolt now goes to the board "brake" to be converted into shingles. The brake in this case, is the narrow "Y" crotch of a black gum tree cut about six feet long. The single end is propped up, and two stout poles are crossed in the double end. No nails or other braces are needed, for these poles wedge firmly enough to hold the end up. As one man said, "They work contrary to each other."
>
> The top surface of the brake should be level. Then a block is placed underneath on which the bolt being split is rested.
>
> The bolt standing on end between the two arms of the brake, Bill places his froe against the bolt end and... strikes it sharply several times with the mallet thus driving the froe's blade into the bolt.

Board "Brake" (Wigginton, p. 48)

> Now, using the board brake as leverage and a brace, the shingle is pried off. The tendency is for the crack to move steadily toward the top of the bolt (or "run out"), thus making your shingles narrower at one end than at the other. To prevent this, the moment Bill sees the crack running out, he turns the whole bolt over, leaving the froe in place, and continues prying from this position. Pushing down on the bottom half of the bolt will cause the crack to come back toward the middle also. Let up, and again it moves to the top. If, when the bolt has been halved, the shingles are still too thick, each can be halved again using the same process.
>
> Bill prefers removing the sap from the finished shingle since the sap is softer and rots quickly when exposed to the weather (Wigginton, pp. 48-50).

The methods of manufacturing wood shingles were described somewhat indirectly by Henry C. Mercer while explaining the tools of the shingle maker. Captioning an illustration of a variety of frows are the comments:

> Having placed a block (red oak in Pennsylvania) about eighteen inches long and squared, or quartered from the log, to the required five-inch width, the worker, holding the handle vertically in the left hand, sets the heavy, wide-backed blade of the instrument, on the top of the block placed vertically in the tree fork frow horse.... He then strikes the back of the blade, beyond its projecting end, continued blows with the club..., while he wriggles the handle, if necessary, so as to hurry the split, or regulate the depth of the cut, until a segment of the block, – the shingle, flies off (Mercer, p. 13).

Halving the Bolt (Wigginton, p. 50)

A description of manufacturing shingles without the assistance of a shingle horse comes from H.L. Edlin:

> ...one man held the froe with its blade on the end face of the split log, keeping it on the radius running to the centre of the tree, whilst another fellow struck the froe a hearty blow with his mallet, so splitting off a shingle. Several shingles could be cut in turn from each log... (Edlin, p. 94).

Removing the Sap from the Finished Shingle.
(Wigginton, p. 50)

The circular "shingle saw" driven by horsepower mentioned earlier is representative of a wide variety of shingle machines which came on the market in the mid-19th century. It had:

> ...a circular blade about 30 in. in diameter. A lever with a clamp holds the block, which is pressed against the cutting edge of the blade (Nelson and Dalibard, p. 57).

3.2.3 Dressing (Punching and Butting)

The manufacture of wood shingles often included the extra step referred to as dressing. The split shingle was held by an instrument known as a shaving horse and shaved with a drawing knife.

Edwin C. Guillet in *Pioneer Arts and Crafts* described the use and operation of the shaving horse:

> Many of the most enterprising farmers constructed a shaving-horse, which was a combination of work-bench and vice. It was usually higher at one end than the other, and the worker sat astride the lower and narrower end, while through an opening in the bench in front of him projected the head of a clutch swinging on a pin which passed from one side to the other through the body of the bench or horse. Upon a transverse piece of wood on the lower end of the clutch, the operator placed his feet, and by pressing it from him he brought the head of the clutch down upon any object placed under it, and so held it firmly upon the horse. A draw knife with handles at both ends was used to shave or cut the wood held in the shaving horse, and it was particularly valuable in shaving and dressing shingles after they were split. Laths were similarly prepared (Guillet, pp. 6-7).

Another operation which was sometimes carried out on the wood shingle prior to placement was the making of preparatory nail holes. Mercer illustrated a shingle punch which was used instead of a gimlet in some instances (see Definitions). The text which accompanies the illustration stated:

> When that part of the riven shingle intended to be exposed to the weather on the roof is inserted into the guide, a down-push of the lever forces the chisel-shaped iron punch (always set across the grain) through the shingle at the lower corner where the needed corner nail, freshly driven into red oak, might split the wood. Otherwise a gimlet was used. Riven shingles were set in Pennsylvannia, to overlap, not only at the top, but at the sides; hence these nails, to

> prevent upcurling at the exposed corners. Shingles were made of easily split red oak, hence the punch, not necessary with later imported cypress shingles. The punch or gimlet was probably not used in New England, with pine. Joseph N. Gross used this instrument near New Galena, Bucks Co., Pa., about 1880, as seen by his son, Henry Gross, of Doylestown, the writer's informant (Mercer, p. 18).

Another method of preparing nail holes was mentioned by Donald W. Insall in *The Care of Old Buildings Today: A Practical Guide:*

> On the rare occasions when shingles are to be renewed in oak, the nail-holes must be burned with a hot iron, as protection to the nails against tannic acid attack (Insall, p. 107).

Another operation which could be carried out was a trimming or "butting" of the shingle. A machine for this purpose was both illustrated and described by Mercer:

> This homemade machine used to trim off or bevel (supposedly for looks' sake) the often uneven lower ends of riven shingles, was used in Bucks Co., Pa., until about 1890. By pressing the lever, the knife slides down upon the shingle thrust on its side, and at an angle under it. ....Its probable date is about 1850 (Mercer, p. 17).

The lack of documentation on the punching or burning of nail holes and trimming operations generally and the total lack of Canadian material on this subject, frustrates any attempt to generalize on this aspect of shingle making.

3.3 MACHINE MANUFACTURE

3.3.1 Preparing the Blocks

The Certigrade Handbook of Red Cedar Shingles, first published in 1936, contained an excellent description of a shingle mill operation:

> *How Shingle Bolts Are Produced*
>
> Sometimes the large cedar trees are felled before other logging begins, particularly in smaller operations, and instead of sawing or "bucking" the trees into log lengths, short sections a trifle longer than 48 inches (or 54 inches, as the case may be) are cut. These sections are split with heavy mauls and wedges into "bolts", much resembling overgrown cordwood in appearance, for more convenient transportation to the shingle mill in the absence of logging machinery. At the saw-mill, these bolts are cut into blocks 16, 18, or 24 inches in length by means of "equalizer" saws, spaced the proper distance apart.
>
> • • • •
>
> By far the greater proportion of the cedar used for the manufacture of shingles comes to the mill in the form of logs. Sorting and handling of these logs, which are usually cut to long lengths in the woods, is possible only when they are floating in water, and therefore all log mills are provided with log ponds. Power machinery in the ponds is commonly used in cutting the logs to shorter lengths so that the mill can be supplied with logs that will produce the grades of shingles that are being manufactured in the proper proportion.
>
> • • • •
>
> The logs are hauled up into the mill in a massive chute equipped with a huge endless, power-driven, conveyor chain, known as a "log haul". At the mill-end of the log haul, heavy steel stops arrest the forward motion of the log as giant steel clamps, actuated by a large steam cylinder and piston, hold it firmly in place, the log haul drive being thrown out of gear. A large circular saw (as large as ten feet in diameter) with high-speed inserted teeth or bits which cut through the log rapidly and which plane the sides of the cut smoothly as they go through, cuts the log into 16, 18, or 24 inches lengths with precision, the length of the section cut being determined by the spacing of the steel stop that is used. Some logs are so large that even a huge saw of this diameter is too small. To reduce such logs to short lengths, a very large auxiliary steam driven drag saw is usually provided.
>
> • • • •
>
> The large log sections of the proper length must next be split or cut to the proper sizes of blocks for the shingle machines. In doing this, they are quartered, split and requartered, until they are of a convenient size, every effort being made to make blocks that have a true edge-grain face (Grondal, pp. 10-11).

Ralph W. Andrews in *This was Sawmilling* devoted a chapter to turn-of-the-century shingle manufacturing in the western United States. He described the process of preparing logs for conversion to shingles:

> Shingle bolts were cut 52" in the woods, 20 to 40 bolts to the cord. They were skidded by horses and sleds directly to mills or dumped in rivers and floated down the mills in booms. Some mills not on rivers used flumes to get the bolts in.
>
> Cut off saws divided the bolts into 16", 18" and 24" lengths. These blocks dropped to belts or carriages which brought them up against smaller, quartering saws which cut across the diameter, turned them and cut at right angles to the first cut. This gave blocks proper size for handling and opened the grain for cutting vertical or edgegrain shingles.
>
> Blocks then went to a third saw which trimmed off bark and surface defects, then up a conveyor to the second floor and shingle machines (Andrews, p. 132).

3.3.2 Conversion to Shingles

The action of a shingle machine was briefly described by Andrews:

> Blocks were placed in machines so saws cut against the face, blocks shifting backward and forward, the top extending farther than the bottom on one forward movement and reversely on the next movement, the wedge shape being produced (Andrews, p. 132).

On the same subject Grondal stated:

> In sawing shingles, it is now virtually universal practice to use so-called "upright machines," so that one sawyer can joint or edge and grade the shingles that are cut from one single block. This permits the sawyer to readjust the block from time to time so that the highest possible grade of shingles will always be produced. This type of shingle machine is equipped with a reciprocating, power-driven carriage, which carries the block past a thin-gauge, razor-sharp circular saw, which cuts off a shingle smoothly at each stroke. On each return stroke of the carriage pawls engage with the feed rolls between which the block is firmly held, the upper feed roll and the lower feed roll being alternately turned so that a tapered shingle with the butt either up or down is cut at each stroke.
>
> • • • •
>
> The sawyer picks up each shingle as it comes from the saw, places it on a "springboard" with the butt held firmly against a guide which is exactly at right angles to the blade of a second circular saw, and presses the springboard down so that the overhanging edge of the shingle is clipped off smoothly. Flipping the shingle over in his hand, he repeats the process, making another smooth edge parallel to the one first cut. If defects were present in the shingle as it came from the saw, he joints the shingle in such a way that a narrower shingle, or two shingles, without defects, can be obtained. The sawyer then drops the shingle into the proper chute, depending upon the grade, which leads to the packing bins below (Grondal, pp. 11-12).

3.4 DIMENSIONS

The subject of shingle dimension is a complex and difficult one. The many factors affecting the choice of dimensions (i.e. available wood, limitations of tools and machinery, local preference, etc.) have produced a confusing array of shingle shapes and sizes. When a particular time period is selected, and a particular region of the country chosen, the problems are somewhat eased. Guillet, focussing on the pioneering period in Upper Canada ventured that: "The first shingles were about three feet long…barn shingles were often four feet long…" (Guillet, p. 6).

A check of written sources in the period before the adoption of the circular saw for most shingle manufacture (taken as 1830-40) reveals a wide ranging set of dimensions.

> *Boston Newsletter,* October 19-26, 1713. Shingles. By enactment of the General Assembly of the Island of Barbadoes, all shingles imported from New England must be not less than 18 1/2 in. long, 5 in. wide and half an inch thick (Nelson and Dalibard, p. 31).
>
> • • • •
>
> An examination of over 200 whole and fragmentary specimens from excavations suggested that wooden shingles used at Louisbourg during the eighteenth century tended to be...ie. Approximately 1.40' [1'-5 in.] x .50' [6 in.] x .03' [3/8 in.] (butt) and .01' [1/8 in.] (feather) where taper present (Cox, p. 69).
>
> • • • •

Record of Vessels Entered at the Port of Baltimore, Aug. 1, 1782 – Aug. 24, 1784.

Oct. 21, 1782	Schooner Two Brothers, Currituck, N.C. 11,500 shingles
Apr. 21, 1783	Schooner Squirrell, Curituck, N.C. 9,000 3 ft. shingles 10,000 18 inch shingles
Apr. 26, 1784	Schooner Providence Roanoke 7,851 3 feet shingles 46,974 2 feet shingles 76,128 18 inch shingles

(Nelson and Dalibard, p. 45).

• • • •

The Rules of Work of the Carpenters' Company of the City and County of Philadelphia 1786. New lathing and shingling with 3 feet shingles... Ditto, with 2 feet shingles... Lathing and shingling with 18 inch shingles, 5 inches wide… And with the common 18 inch shingles… (Peterson, pp. 5-6).

• • • •

Estimate of the Expense required to erect a stable of 3 stalls at Butler's Barrack for Regimental staff officers... [30 January, 1819] 4000 – 18 Inch Pine Shingles (McConnell, p.146).

If there are any conclusions on shingle lengths to be drawn from the above references and the much larger pool of references it is that no single length of shingle dominated the market; relatively short shingles 15 in. - 24 in. are as frequently encountered as the longer 33 in. - 36 in. shingles, and the most popular lengths were clearly the 18 in., 24 in. and 36 in. sizes. The meagre descriptions of shingle width and thickness provided by the same sources is insufficient for making any conclusions.

The percentage of machine-made shingles increased steadily throughout the 19th century. Within the limits imposed by the sawing mechanism, the flexibility was great. The August 17, 1821 issue of the *Quebec Mercury* carried the advertisement:

> John Goudie advertises for sale at his steam saw mill, St. Roch suburb of Quebec City, millsawn shingles of all lengths and sizes (Nelson and Dalibard, p. 30).

A review of written sources in the period 1840 to the present, a period dominated by the circular sawn red cedar product, and which has seen a revived interest in the hand-split shake, reveals a decided shift in popular shingle dimensions (See Brees, 1853; Plummer, 1869; Clark, 1886; Trautwine, 1887; Mortimer, 1901; ICS Reference Library, 1903; Kidder, 1915; Macey, 1922; Ramsey and Sleeper, 1941; Fickes and Groben, 1974; Edlin, 1973; Parker, 1958; Grondal, 1964; Clark, 1971.)

Some patterns emerge from the post-1840 references. Hand-split oak shingles (Brees, Macey and Edlin) are 4, 6 or 8 in. wide and generally 8, 10 or 12 in. long. They are consistently smaller than shingles of other species. Two streams of development are evident: the shaves or breasted shingle (later referred to as the shake); and the sawed shingle. In the case of the former, 18 in., 20 in., 24 in., and 27 in. lengths and butt dimensions of $^{5}/_{8}$ in. to 1 $^{1}/_{4}$ in. predominate. In the case of sawed shingles, the lengths 16 in., 18 in. and 24 in. predominate. Random widths, 2 $^{1}/_{2}$ in. or 3 in. minimum and 14 in. or 16 in. maximum are preferred. Dimension shingles 4, 5 or 6 in. wide are also available. Butt thicknesses are generally standardized at 5/2 in. for 16 in. shingles, 5/2 $^{1}/_{4}$ in. for 18 in. shingles and 4/2 in. for 24 in. shingles. Extra thick sawn shingles, available from the mid-1800s seem to disappear in the mid-1940s.

3.5 GRADING

To ensure consistent and reliable manufacture of shingles, various organizations have been created to establish grading and packing rules and ensure conformance to those rules. Some of these are the Pacific Coast Lumber Manufacturers Association, the Southern Pine Association, the British Columbia Lumber and Shingle Manufacturers, Limited, and the Red Cedar Shingle and Handsplit Shake Bureau. For each wood type, there are specified grades of shingles that are commonly manufactured. In the case of red cedar, three grades are currently produced. A No. 1 Blue Label (strictly edge-grain, all heartwood, entirely "clear"), a Red Label (clear or free from blemishes for 10 inches of their length as measured from the butt, maximum width of only one inch of sapwood in the first 10 inches, a mixture of vertical and flat-grain), and a No. 3 Black Label (clear for bottom 6 in. of their length). In the case of red cedar shakes, only a single No. 1 grade is produced at the present time. It requires 100 percent clear material, 100 percent heartwood, free of bark and sapwood, except that $^{1}/_{8}$ inch of sapwood is permitted on one edge. Tapersplit and straight-split are required to have 100 percent edge-grain, handsplit and resawn, not to exceed ten percent of flat-grain in the lineal inches of any bundle.

Over the years, different terminology has been used to identify grades of shingles. As late as 1964 the *Certigrade Handbook of Red Cedar Shingles* acknowledged that No. 1 Blue Label 16 in. shingles were also called "Five X", (written XXXXX), No. 1 Blue Label 18 in. shingles, "Perfections" and No. 1 Blue Label 24 in. shingles, "Royals". In the *Standard Classification, Grading and Hemlock Lumber and Red Cedar Shingles*, March 28, 1908, were the grades, Perfection – 18 in., Pudget A-18 in., Eureka – 18" Skagit A-18", Extra Clear – 16" Choice A-16", Extra A-16" and Standard A-16" (Pacific Coast Lumber Mfrs. Assoc., p. 33).

Another system of grading is described in the International Correspondence Schools (ICS) Reference Library series. It may predate some of the west-coast systems:

> Strictly first-class shingles are generally given a brand of "xxx", and those of a slightly poorer quality are termed No. 2; but in some sections of the country, the brand "A" is general; thus, "Choice A" or "Standard A" are practically equivalent to the "xxx" shingle (No. 14, pp. 19, 28).
>
> *Light Frame House Construction*, a reprint of a 1940 publication, is one of the few sources which relates grade to the various species of wood used for shingles. The recommended grades of shingles are:

Species	*Permanent construction*	*Temporary more economic construction*
Red Cedar Shingle Bureau	A-B	B.-C.
Western red cedar Washington and Oregon Shingle Assoc.	A-B	B.-C.
Cypress (Southern Cypress Manufacturers' Association)	Bests	Prime or star.
Redwood (California Redwood Association)	Clear V.G.	Star A
Northern white cedar	Extra A	Standardw
Southern pine (Southern Pine Association)	Select	No. 1.

(U.S. Department of Commerce, p. 141).

3.6 PACKING OR BUNDLING

The tradition of packing shingles in bundles is an old one. It is not, as one might suspect, a development of the large West Coast shingle mills, concerned with shipping a massive output of sawn cedar shingles.

One method of packing and selling shingles was by the "number of units" method. The earliest reference, ca. 1811, to a bundle is of this type:

> By a supplement passed in 1790, shingles of the third sort are required to be packed in a close and compact manner, when sold in bundles; each of which shall contain one hundred and twenty five shingles, and no more: and each row in every bundle must only contain three shingles (Nelson and Dalibard, p. 49).

In such cases where random shingles were being packed, every 4 inches of shingle width was counted as one shingle. The tradition of selling by this method was of long duration.

The second method of packing and selling shingles was by the "square pack." Present practice also employs this system.

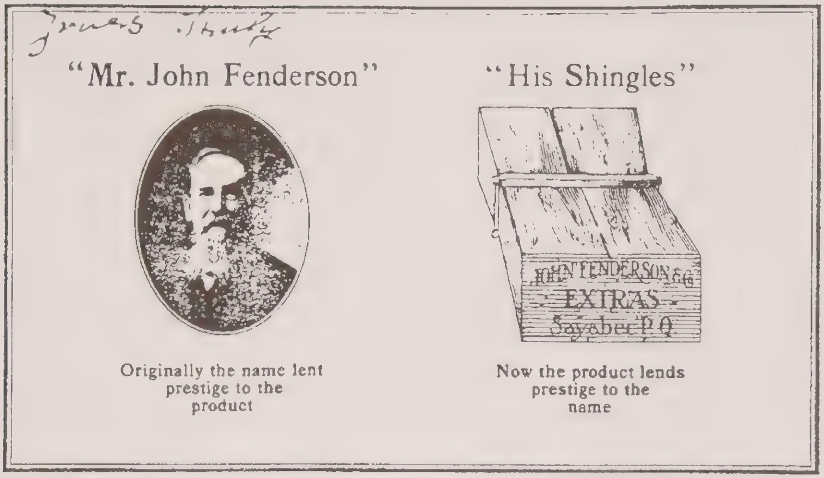
> In the square pack, the shingles are packed in such a way that a prescribed number of bundles, at a specified exposure of the shingles to the weather, will cover an area of 100 square feet known as a "square" (Canada. Dept. of Resources and Development, p. 7).

The construction of the bundle, with its special terminology was discussed by Grondal:

> ... shingles are packed in conventional bundles because this form of package is conveniently handled both at the mill and on the job, and is, moreover, very economical. The two sticks between which the ends of the shingles are tightly gripped are known as "band sticks", and they are always made of good straight lumber. The metal straps connecting these band sticks are known as "bands". Packaged in this manner, the bundled shingles are easily dried or seasoned, remaining perfectly flat in the process (Grondal, p. 23).

The arrangement of shingles within a typical bundle is discussed by *Canadian Woods Their Properties and Uses*:

> Shingles are packed in forms of fixed width, edge to edge, with the thin ends overlapping. The layers at each end of the bundle are known as "courses", and the total number of courses multiplied by the width of the pack is expressed as "running inches". The number of running inches required for a square varies with the exposure allowance in laying (Canada. Dept. of Resources and Development, p. 7).



Courtesy of K. Elder

An advertising postcard of a Quebec shingle manufacture ca. 1908, showing a typical bundle of shingles

It is suspected that other methods of selling shingles were employed historically, which had neither an even number of shingles per bundle nor an amount sufficient to cover an even division of a square. A reference to such a bundle was provided by P.W. Plumer in 1869:

> Shingles are usually 16 inches long, and a bundle of shingles is 20 inches wide, and contains 24 courses in thickness at each end; hence a bundle of shingles will lay one course 80 feet long (Plumer, p. 9).

Most roofing shingles and shakes today continue to be packed in bundles. This is not true, however, of certain sidewall shingle products – i.e. No. 1 and 2 rebutted and rejointed shingles and No. 1 grooved sidewall shakes are packed today in cardboard cartons.

3.7 SEASONING

Generally shingles are cut from greenwood. A. Viires acknowledged this practice and then added:

> If a tree has been cut sometime before, it is soaked in water for several weeks before shingle cutting begins (Viires, p. 189).

No sources have been located which detail the seasoning of hand split shingles. H.L. Edlin, following his discussion on how shingles were split, added the comment:

> ...they were ready for immediate use, though seasoning improved them (Edlin, p. 94).

Descriptions of seasoning saw shingles are more common. Describing a west coast shingle mill at the turn of the century Andrews stated:

> Conveyor belts took bundles to dry kilns where they took the steam heat treatment for ten days to two weeks, a slow method to keep shingles from splitting. By this time the wood had contracted and the bundles had to be retied (Andrews, p. 133).

A good description of air-drying and kiln-drying sawn red cedar shingles was provided by Grondal:

> As shingles are packed or bundled immediately after sawing, they are, at this stage, in a "green" or unseasoned condition. The moisture content of the wood is well above the fiber-saturation point, and consequently no shrinkage has taken place. At this point, a decision must be made as to the subsequent procedure that will be advisable. The shingles may be sold and shipped as *green, air-dry or kiln-dry.*

Green and Air-Dried Shingles

> Shingles are packed immediately after they are sawed and many shingles are shipped without further processing. The initial moisture content of western red cedar wood is variable. The heartwood of cedar trees growing at high elevations often contains as little as 40 percent of moisture based on the dry weight of the wood, while low-land cedar may be much higher in moisture content.
>
> Air-seasoning is accomplished by stacking the shingles in the yard or under a shed roof. After a period of time, depending upon prevailing climatic conditions, shingles will reach a satisfactory moisture content for application on sidewalls or roofs, to give characteristically normal, trouble-free service.
>
> *Kiln-Drying Demands "Air-Conditioning"*
>
> In commercial practice for rail shipments the process known as "kiln-drying" has been generally adopted. In this process, the shingles are placed in a room in which weather conditions are under absolute control, the temperature being maintained at the desired point by automatic controllers, in the same manner as the temperature is regulated in air-conditioned houses. Moreover, the relative humidity, which at any given temperature is the most important factor in controlling the rate and extent of drying, is also regulated and maintained at the most desirable level (Grondal, p. 13)

Both Grondal and Andrews pointed out that in the past, attempts were made to remove all of the moisture to save freight charges. This could only be done by using very high temperatures, with the result that shingles were "baked" dry, making the wood brittle and causing actual damage to the wood structure.

4.0 FLASHINGS

4.1 TIN PLATE AND TERNE PLATE

Two materials which were used as a flashing material for wood shingle roofs at a very early date were tin plate and terne plate. At times sources fail to differentiate between the two, using the more popular "tinplate" to describe both. The physical properties of both products are, however, distinctly different. Terne is a lead and tin alloy (today 80 percent lead, 20 percent tin) coating applied to iron or steel sheet. The finished surface appears dull. Tin plate, as its name implies, is 100 percent tin coated iron or steel sheet. The surface appears shiny, which led to calling them "bright plates."

References to these flashing materials on a wood shingle roof are some of the earliest found:

> *Constitution of the Incorporated Practical House Carpenters' Society of the City and County of Philadelphia together with Rules and Regulations for Measuring and Valuing House Carpenters' Work*, Philadelphia: 1812...
>
> • • • •
>
> Valley gutters prepared for tin or copper, per foot running (Nelson and Dalibard, p. 53).
>
> • • • •
>
> ...covered the roof with the best cedar shingles I could find. I hired an honest man to lay them, who would throw out all that were dubious and lay the cross-grained ones right side up, and painted the tin valleys both sides before the shingles were laid (Gardner, p. 246).
>
> • • • •
>
> For stopping the joints between slate (or shingles, etc.) and chimneys, dormer windows etc., a mixture of stiff white-lead paint, as sold by the key, with sand enough to prevent it from running, is very good; especially if protected by a covering of strips of lead, or copper, tin, etc., nailed to the mortar-joints of the chimneys, after being bent so as to enter said joints; which should be scraped out for an inch in depth, and afterward refilled. Mortar protected, in the same way, or even unprotected, is often used for the purpose; but is not equal to the paint and sand. Mortar a few days old (to allow refactory particles of lime to slake), mixed with blacksmith's cinders and molasses, is much for this purpose, and becomes very hard, and effective (Trautwine, p. 429).
>
> • • • •
>
> Some trouble is experienced in shingling valleys straight. The usual custom is to put in a strip of 14-inch tin for the valley, and strike two chalk lines (Hicks, p. 78).

These brief descriptions provide few clues whether tin or terne plate was intended or not. The dates only add to the doubt:

> While bright tin plate was often used for roofing purposes in the early nineteenth century, as terne plate became more readily available it was generally preferred for roofing purposes (Waite, p. 13).

One reference, which almost certainly describes terne plate, comes from a 1909 source:

> All valleys shingled tight and step-flashed with tin .... All tin for flashing used, to be...*roofing tin* painted both sides 2 coats before using (Radford and Johnson, p. 210).

As a 1911 article on roofing explained:

> ...*roofing tin*, consists of thin sheets of steel (black plates) that are coated with an alloy of tin and lead (Trow, 1911: 158).

One of the main disadvantages of tin or terne plate was its easy susceptibility to rust. This is not lost on later writers who continually recommended prepainting:

> All tin shall be painted on both sides before laying, with iron oxide, Venetian red, or metallic brown, and pure linseed oil (Holland and Parker, p. 73).
>
> • • • •
>
> Tin and zinc may be used in cheaper work, but the tin must always be kept well painted.... Tin should not be used as flashing for closed valleys on account of the retained moisture which soon rusts it out (Parker, Gay and MacGuire, pp. 210-11).

One of the most complete discussions on tin and terne plate used as flashing for wood shingle roofs was provided by Grondal:

> *Tin Plate Must Be of Proper Grade*
>
> Unprotected "iron" sheets, even though the steel used in forming these may be "copper bearing," exhibit a rate of corrosion that is too rapid to warrant their consideration, and rust-resistant steel, or "stainless steel" is too expensive for ordinary use. "Tin" usually consists of sheets of mild steel that have been immersed in a bath of molten tin, after which the excess tin, while still in a molten condition, is squeezed off by running the sheets between steel rollers which act as "wringers". The thickness of the coating of tin thus applied can be varied through a wide range, and the cheaper grades are given such a thin coating that the sheets are apt to begin to rust during the first season for exposure. The use of IC tin plate is not recommended; heavier plate, IX, will be necessary to avoid early corrosion. All tin plate should be soldered with half and half solder, using *rosin* as a flux, and should be well painted on both sides before it is placed in position. Tin, as a metal, is very resistant to corrosion, but is soft, and therefore the thin coating on tinned steel sheets is easily scratched through to the steel. If the tin coating is thus broken, the rate of corrosion of the steel becomes extremely rapid, as the tin is "cathodic" to the exposed steel, and the electrolytic effect becomes pronounced. As sharp bends can be made in tin plate without cracking the tin coating, it is a very useful flashing material.
>
> *Terne Plate is Sometimes Used*
>
> Terne plate, or sheet steel coated with an alloy of 75 percent lead and 25 percent tin, of the same weight as the tin plate, IX, is sometimes used, and if properly protected with paint may give good service. All tin or terne plated sheets rust rapidly from the cut edges, where the steel is exposed unless protected with paint (Grondal, pp. 32-33).

4.2 LEAD

The earliest reference to lead flashing in conjunction with a wood shingle roof was quoted by Trautwine in 1887, already reproduced in the section on tin plate. Most later sources, while discussing lead flashing, do not connect its use positively with wood shingle roofs. Two more modern sources, *Material and Methods of Architectural Construction*, 1958 and *Certigrade Handbook of Red Cedar Shingles*, 1964 are exceptions. The former stated:

> Flashing against masonry, such as chimneys or walls, is done by laying pieces of copper, called base flashing, under the shingle, slate, or tile, and bending them up against the masonry.... Another strip of copper or lead, called counter-flashing or cap flashing, is built into the masonry and turned down over the base flashing (Parker, Gay and MacGuire, p. 211).

This practice of using lead in combination with another flashing material, for reasons of economy, or for special physical properties would explain the sample clause for lead flashing provided by Holland and Parker in *Ready-Written Specifications*, 1926 which reads:

Lead Counter-Flashing

> All counter-flashing shall be sheet lead, weighing 3 lbs. per square foot.

The National Building Code currently permits a minimum 0.068-in.-thick sheet lead flashing (NRC, p. 312).

4.3 COPPER

The earliest reference to copper flashing in conjunction with a wood shingle roof is the 1812 Philadelphia reference quoted in 4.1 above. Trautwine, writing in 1887, suggested copper strips be employed at chimneys to protect the paint and sand joint "stopping" (Trautwine, p. 429). Both copper and tin are recommended as gutter lining for a wood shingle roof in the International Library of Technology text. One of the methods of finishing a ridge recommended in 1903 utilized two ridge boards and a ridge roll. No metal was used in the detail. (No. 30, p. 91) Another, later text in the International Library of Technology series mentioned a ridge piece and wooden roll with a copper roll covering (No. 33B, pp. 33, 56).

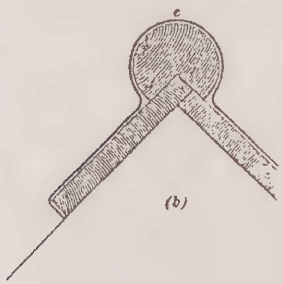


FIG. 37

(No. 33B, p. 56.)

Two texts from the 1950s, *Materials and Methods of Architectural Construction*, and *Architectural Graphic Standards* recommended the use of copper in almost every flashing situation. In the case of the former there is the statement:

> The sealing of all joints between two planes of the same roof or between a roof and intersecting vertical surfaces is of the greatest importance. Such joints are best rendered watertight by the introduction of metal sheets in copper, tin, zinc, or lead. Galvanized steel and composition flashing cannot be depended on. Copper weighing 16 oz per sq ft is by far the best material and should be used wherever possible (Parker, Gay and MacGuire, p. 210).

The text went on to describe copper with wood shingles in open valley, closed valley, against wood walls, against masonry, behind chimneys and other situations.

The latter text included numerous fully annotated flashing details checked by the Copper and Brass Research Association (Ramsey and Sleeper, pp. 195, 198-201). The variety of wood shingle roof situations employing copper include: change of slope, chimney, hip and ridge, top of roof, open and closed valley etc. The temper and weight copper called for in the various situations alternated between 16 oz. and 20 oz. cold rolled copper.

Strangely, more recent trade publications such as the *Red Cedar Shingle and Handsplit Shake Bureau* and those of the *Council of Forest Industries* seem to drop all reference to copper. Whether this is related to cost, products now employed for gutter and downspouts or other factors, is not made clear.

The National Building Code currently permits a minimum 0.014-in-thick copper flashing (NRC, 07, p. 312).

4.4 ZINC

It is suspected that little use was made of sheet-zinc for flashing. Parker, Gay and MacGuire, while including it in a list of metal sheets recommended for flashings add: "tin and zinc may be used in cheaper work, but the tin must always be kept well painted" (Parker, Gay and MacGuire, p. 210).

Some of the problems inherent in the metal are dealt with by two writers:

> Zinc should not be secured by, or connected with, iron, copper, or lead for, in any of these cases, voltaic action is induced, which destroys the zinc (International Library of Technology, No. 33B, pp. 56-76).
>
> • • • •
>
> Note: Zinc can be used safely in direct contact with lead, tin & aluminum. With other metals insulation is required because of electrolysis. Zinc is not affected in contact with most lumber. When used with redwood or red cedar it should be coated with asphaltum paint. Do not use zinc where acid fumes

> occur. Zinc expands 1/4 in. per 10' sheet in temperature change from 0' to 120'. Always use hot-dipped gal. nails with zinc and a glossy, saturated & coated paper under it. May be painted immediately after installation if zinc metallic paint is used (Ramsey and Sleeper, p. 191).

Given that the latter information was supplied by the American Zinc Institute, one suspects their statement on leads is correct. For flashing, leaders and gutters the same authority recommends a .020 in. (10 ga) or thicker zinc be used.

The National Building Code currently permits a minimum 0.018-in. thick zinc flashing (NRC, p. 312). Recent shingle publications totally ignore the material.

4.5 GALVANIZED IRON AND STEEL

Galvanized iron or steel are materials which recently have enjoyed widespread use as flashing materials for wood shingle roofs. This does not, however, appear to have been the pattern in the past. One of the few early references to galvanized iron, used in conjunction with wood shingles, is found in the International Library of Technology text No. 33B, published 1909. A ridge saddle of two boards capped with a wooden roll is "covered with a galvanized iron or copper roll" (pp. 56.33). It is unclear if any wider use of the material is favoured.

Parker, Gay and MacGuire clearly distrusted the material. The statement that "joints are best rendered water-tight by the introduction of metal sheets in copper, tin, zinc, or lead," was followed by: "Galvanized steel and composition flashing cannot be depended on" (Parker, Gay and MacGuire, p. 210).

No such misgivings are expressed by more recent writers. Grondal devoted a good deal of space to galvanized iron and steel flashings.

> Galvanized iron possesses certain superiorities over other coated sheets. It consists of mild steel sheets that have been coated with a layer of zinc by either an electroplating process or by dipping the sheets in a bath of molten zinc. This hot-dipped metal should be used in forming valleys, and it should have at least a 1-1/2 ounce coating (per square foot). Reasonably heavy metal should be used, preferably 24 or 26 gauge, but it is common practice to use 28 gauge sheets and to paint all exposed metal. In making sharp bends in galvanizing iron, there is a tendency to crack the zinc coating, and therefore care should be exercised. Smaller cracks and scratches are not apt to cause corrosion; however, nor do the cut ends. With the steel exposed, rust is anodic (and not cathodic to iron), wasting away very slowly. In the process it prevents the rusting of the iron or steel. Some of the coated sheet metals consist of base sheets of charcoal or other rust-resisting iron. These are much longer lived than mild steel sheets (Grondal, pp. 33-34).

The Council of Forest Industries of British Columbia recommends:

> Flashings shall be at least 26 gauge galvanized iron or ".019" thick aluminum (Council of Forest Industries of British Columbia, p. 2).

The National Building Code currently permits a minimum 0.013 in. thick galvanized steel flashing (NRC, p. 312). This is between a 28 to 30 gauge American Standard Gauge.

4.6 ALUMINIUM

It has not been exactly determined when aluminium first came to be used as a flashing material on wood shingle roofs. In the 1964 edition of the *Certigrade Handbook of Red Cedar Shingles*, however, it was stated that:

> Recently the use of aluminum for valleys and flashings has become general (Grondal, p. 34).

Aluminium is regularly called for in current shingle trade literature:

> Flashings shall be at least 26 gauge galvanized iron or .019 in. thick aluminum (Council of Forest Industries of British Columbia, p. 2).

> Use centre-crimped and painted galvanized or aluminum valleys (Red Cedar Shingle and Handsplit Shake Bureau, p. 2).

The National Building Code currently requires a minimum 0.019 in. thick aluminium (NRC, p. 312).

4.7 OTHER METALS

Certain other less common flashing materials have been used in the past with varying degrees of success. A *Textbook on Sheet-Metal Pattern Drafting* in the International Library of Technology made the comment:

> In addition to galvanized iron, black sheets are coated with alloys and sold under special trade names, as Kalamein, aluminum – coated sheets, leaded iron, etc. (No. 2-A, pp. 17-19).

A "lead-clad" iron, suitable for use as flashing on a wood shingle roof was listed by Grondal:

> Lead-clad iron, or steel sheets coated with a comparatively heavy coating of lead are now on the market, and if used in weights no thinner than 28 gauge, will give good service (Grondal, p. 33).

A lead-coated copper (core metal-copper .0217 in. thick with a coating of 96 percent lead, 4 percent tin) is an architectural metal which may also have found some use as a roof flashing. It is included in a Follansbee Steel Corporation brochure, in comparison with a terne-coated stainless steel product it manufactures.

Undoubtedly, occasional use was made of composition materials. The present building code permits roll roofing materials to be used in valley situations.

5.0 BUILDING FELTS AND PAPERS

5.1 EAVE PROTECTION

No early references to felts or papers used as an eave protection have been located. The apparent neglect of such protection does not appear to be related to the availability of a suitable material or a misunderstanding of the source of water entry at the eaves. J.W. Patterson and Bro., Importers and Manufacturers of Tarred Building Paper, Dry Building Paper, etc., a Toronto firm, were the subject of a commercial sketch in 1886 (Bixby, M.C. and Co., p. 95). On the subject of eave detailing, we have the comment in the International Library of Technology text No. 30, concerning ice dams, one of the most frequently given reasons today for using eave protection:

> Great care must be observed along the eaves of a roof, especially where that roof is over a well heated room, as the interior heat will, during the winter, cause the snow on the roof to melt and run to the eaves, where, relieved from the effects of the high temperature, it freezes and builds up a dam of ice, and the accumulated water backs under the shingles and gets into the house. Under these conditions it is sometimes desirable to build the gutter above the line of the plate, in order that the same heat that melts the snow may sufficiently warm the gutter to prevent it from freezing up when its services are most needed (International Textbook Co., pp. 95-96).

Clearly there was by the turn of the century an awareness of the problem, its cause and materials available for its correction. The reasons why it was not adopted earlier are unclear. One possibility is that the earlier forms of gutter took better care of the problem than the stock galvanized iron gutters which followed. Another possibility is that the thick shingles (shakes) which enjoyed an increased popularity in this century did not give a sufficiently tight roof and therefore eave protection was developed to meet the need. Whatever the reason, by mid-century eave protection was generally specified.

The materials approved by the 1977 National Building Code for use as an eave protection are 6-mil-polyethylene, No. 15 asphalt-saturated felt and 45-lb. roll roofing (NBC, p. 314). The same materials were specified in the 1965 code.

5.2 UNDERLAYMENT

Unlike eave protection, some early references to felts and papers used as an underlayment are found. Unfortunately the general nature of the description makes a precise identification of the material difficult. T.M. Clark, writing in 1886, described a roof construction:

> Where shingles are to be used, the roof boarding is generally of hemlock off inferior spruce, planed to an even thickness, and one or two "piles" of tarred felt are laid under the shingles, to prevent fine snow in heavy storms from finding its way into the rooms (T.M. Clark, p. 149).

The same author provided a sample specification for the carpenter's work. Under the heading "Roofing" an expanded description of "tarred felt" was given:

> Cover all the roofs, including those of porch and piazza, with good hemlock boards, planed one side to an even thickness, and well nailed to every rafter, two plies of pine-tarred felt paper, breaking joint (T.M. Clark, p. 231).

A contract between the Department of Public Works and the contractor William J. Barker, Sept. 25, 1866, for the construction of a stable, provides another reference to underlayment:

> Roofs to be covered with boarding laid close and well nailed to each rafter and all to be covered with shingles laid on tarred paper (Hildebrandt, p. 182).

The International Library of Technology text No. 31 detailed a method of laying shingles which incorporated a "roofing felt" (pp. 13-32). No information on the felt was provided. A 1921 sample specification provided by the Pacific Lumber Company of Illinois for its redwood shingles and shakes called for a layer of "waterproof paper." Once again, no precise description of the material was provided (*American Architect,* p. 78).

The comments on underlayment made by Grondal recognized the different characteristics of a saturated paper or felt and a material which breathed:

> Saturated building paper should not be applied to the roof deck before the shingles are laid. If added insulation is wanted, or it seems desirable to insure against air infiltration, the roof may be covered with rosin-sized building paper, "dry" or unsaturated "deadening" felt or light-weight "blue" wallboard. Some architects prefer to specify the use of asbestos paper, which offers no disadvantages, and may, under certain circumstances, prove desirable. The use of insulating boards over the roof deck is not recommended, for these do not provide the necessary strength to support the nails even if longer nails which penetrates the sheathing are used (Grondal, p. 31-32).

Grondal went on to state that these same materials could be added to both an open or solid decking.

The current National Building Code requires that a breather type underlayment be used beneath shingles and shakes (NBC, pp. 314, 316). In the case of wood shingles this is generally interpreted to mean a No. 15 perforated asphalt-saturated felt. In the case of wood shakes this is most often interpreted as a 25 lb. or 30 lb. perforated asphalt-saturated roofing felt.

6.0 FASTENERS

A traditional method of fixing shingles to lath and board roof members using wooden pins was mentioned by a number of writers such as Guillet, Clifton and Taylor and Edlin. The same writers, unfortunately, failed to note the type of wood used for making the pin, its size and shape and the period of its popularity.

The most common method of attaching shingles was and still is nailing. The earliest nails were of the hand-wrought iron type. Archaeological research at Louisbourg, N.S., uncovered iron shingle nails with broad faceted heads, four sided tapering shanks, approx. 10 ft. [1-1/4 in.] in length (Cox, p. 68). They are dated pre-1780.

A *List of Nails and Spikes*, prepared by the Royal Engineers Office, Halifax in 1812, included two nails, presumably for use with wood shingles, identified as "fine shingle, rose headed." The larger, roughly 2 in. (according to an illustration provided) weighs 7 lbs./1000. The shorter, roughly 1 1/8 in. weighs 4 lbs./1000. Each has a broad faceted head, four sided tapering shank and sharp point. Although not stated as such, they are obviously hand-wrought from soft malleable iron.

Estimates from the early 19th century frequently referred to 4d (1-1/2 in.) and 6d (2 in.) shingle nail lengths. The latter may have been reserved for extra thick shingles, finishing hips and ridges or for over-roofing existing wood shingles.

Wrought nails (Mercer, p. 236)

As early as the 1790s in the United States and the 1860s in Canada, nails were manufactured by cut-nail making machinery. Despite the saving which could be effected by using these nails, at least one writer retained his preference for the hand-wrought product:

> Two nails are used to each shingle, near its upper end. They should not be of less size than 400 to a lb.* Wrought nails being the strongest, are the best; cut ones are apt to break by the warping of the shingles (Trautwine, p. 429).
>
> * A pound of 3d common nails, 1-1/4 in. long, would yield approximately 400 nails (Finch and Apgar, p. 172).

An early reference to galvanizing is found in *Building Superintendence*:

> Each [shingle] must be nailed with two nails, which should be galvanized if a very permanent roof is desired. Common nails rust out long before good shingles, while painted, become unserviceable (T.M. Clark, p. 148).

Wire nails of a length suitable for wood shingles were first manufactured in the United States ca. 1885. They did not dominate the market until the late 1890s.

The third edition of the *Canadian Contractor's Handbook and Estimator* provided several rules of thumb for determining the number of nails required to lay a set amount of shingles. Indirectly it provided the information that standard 16 in. sawn shingles were nailed with 3d [1-1/4 in.] nails and the handsplit pine shingle with 4d [1-1/2 in.] nails.

Grondal recommended 3d and 4d nails for new construction, 5d and 6d nails for overroofing, and 5d nails for double coursing. He recommended that the nail size be chosen to allow a minimum one-half inch penetration into the roof sheathing.

The use of hot-dipped galvanized nails has been recommended in most 20th-century publications. A chart of appropriate nail sizes for various shingle lengths was provided in *Architectural Specifications*, a 1940 publication:

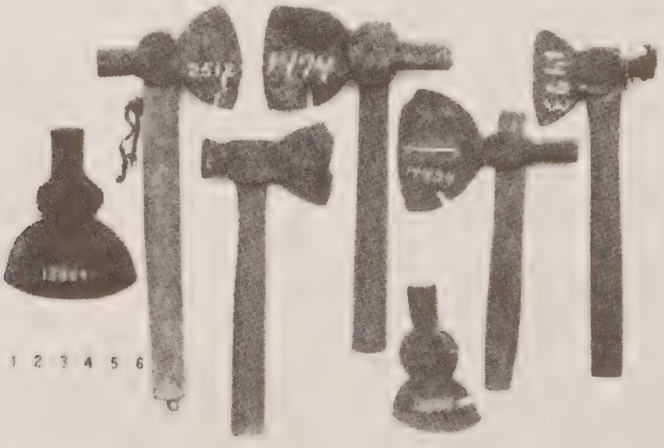
> (b) Nail sizes shall be
> - for 16" standard shingle, 3d or 3-1/2d.
> - for 16" extra thick shingle, 6d.
> - for 18" standard shingle, 3d or 3-1/2d.
> - for 24" standard shingle, 4d.
> - for 24" extra thick shingle, 6d.
> - for 24" shakes or resawn shingle, 6d.
> - for 30" to 37 in. shingle, 8d.
>
> (Sleeper, p. 388).

More recent publications call for "rust resistant" nails for both shingles and shakes. This is interpreted as either hot-dipped zinc coated or aluminium.

7.0 SHINGLING TOOLS

One of the most important tools of the shingler was and is the "carpenter's shingling hatchet." As far is its origins go, Mercer commented:

> Though probably not much used in England, where slate and thatch precluded it throughout the 18th century and where it appears (in Moxon) [1703] as a bricklayer's lathing tool, nail-notch and all; the evidence shows that in the United States, owing to the superabundance of shingled house roofs, it had replaced the



The Carpenter's Shingling Hatchet (Mercer, p. 28)

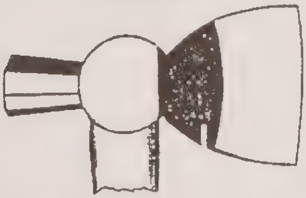
old hewing hatchet and become a typical carpenter's tool by the end of the 18th century (Mercer, p. 89).

Mercer described the tool:

> This... was and is a one-hand tool of miniature, broad-axe shape, with blade not basilled, but always with an elongated or rounded poll for driving nails, and a straight, ten to twelve inch handle,... rarely without a notch in the lower rim of the bit for nail pulling, and hence particularly adapted for use of the worker, who, in shingling a house roof, could trim, split to fit, and nail on shingles with this single instrument (Mercer, pp. 88-89).

A list of tools made by Amasa Thompson in Middleborough, Mass., 1827 included a shingling hatchet (Welsh, p. 192). A J.B. Shannon trade catalogue of 1873 lists four shingling hatchets, manufactured by John Beatty & Co (Shannon, p. 66). The shape of the head is similar to those illustrated by Mercer.

JOHN BEATTY & CO.'S CAST STEEL SHINGLING HATCHETS.
WARRANTED.



No. 1...John Beatty & Co.'s Cast Steel Shingling Hatchets,	each,	70c.
No. 2. John Beatty & Co.'s Cast Steel Shingling Hatchets,	each,	75
No. 3. John Beatty & Co.'s Cast Steel Shingling Hatchets,	each,	75
No. 4. John Beatty & Co.'s Cast Steel Shingling Hatchets,	each,	80

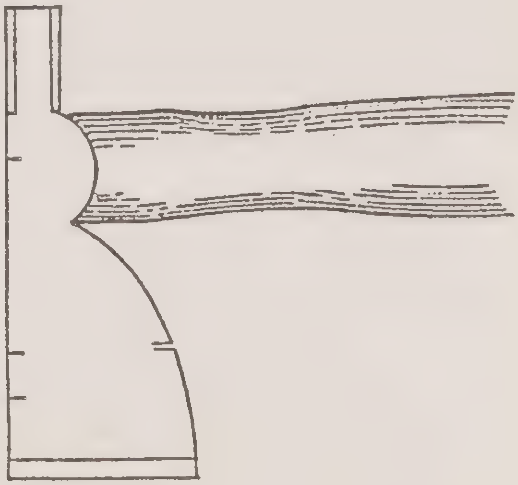
Shannon, p. 66

Eric Sloane's sketchbook of early American tools included an illustration of a shingling hatchet. The string on the end of the handle was explained:

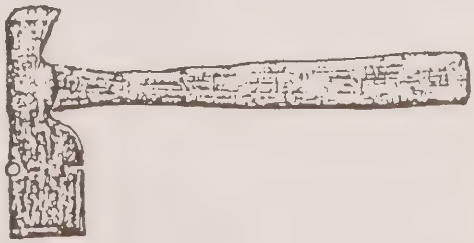
> Shingling hatchets so often fell from roofs being worked on that roofers frequently had them strung for hanging at the wrist (Sloane, p. 20).

Some later writers, on the subject of shingling a roof, illustrated a quite different hatchet. *Radford's Cyclopedia of Construction, Carpentry, Building and Architecture* showed a "very common shingling hatchet" which has every appearance of being a lathing hatchet. It is flat-topped and was often used as a rule for marking off overhang and exposure:

> File marks at one and one-half and two inches (the projection that is generally used on a barn or shed roof – as most houses nowadays have gutters) and other marks at four and one-half and five inches (which are ordinary courses), and it makes a very convenient all-around rule, hammer and hatchet, and in the hands of a mechanic a very good roof can be laid even without the aid of chalk lines or straight edge (Radford and Johnson. Vol. 2, p. 227).



Radford, 1909, p. 227



Siegele, p. 208

Shingling Hatchet (Sloane, p. 21)

Siegele, writing in 1942 and Grondal in 1964 illustrated shingling hatchets with an adjustable weather exposure gauge attached. They are flat-topped; i.e. lack the upper projection of the eye and bit. Both adopted the traditional lathing hatchet shape. "Shingle-and-lath" hatches, similar to those illustrated by Siegele and Grondal, but without the gauge, are currently available from most hardware outlets.

No other specialized hand tool was regularly used by the shingler. Chalklines, rules and other tools generally carried by the carpenter need no explanation. Scaffolding, toe holts, shingling stools and other apparatus employed in securing a footing are described in 9.7 and 9.8 and below.

8.0 SHINGLE STAIN AND PAINT

The use of paints and other finishes on a wood shingle roof would appear to be almost as old as the use of shingles themselves. A survey of a house in Philadelphia carried out February 5, 1754, included:

> …old shingling parged with Tarr & Spanish Brown… (Nelson and Dalibard, p. 45).

A letter dated August 13, 1783, from George Washington to Lund Washington included:

> …the Paint and Oil which has been expended on them [new shingles] will, in a great measure be preserved (Nelson and Dalibard, p. 39).

By the late 1800s the painting of shingles was so commonplace that T.M. Clark mentions it as a possible criterion for the selection of an appropriate shingle:

> The choice between sawed and shaved shingles depends upon circumstances. The latter allow water to run off more freely, and are to be preferred if unpainted, while the former hold paint better, and are therefore generally used by architects (T.M. Clark, pp. 148-49).

Although never spelled out, a standard lead and oil paint was probably used.

Twentieth-century sources rarely mention paint as a roof shingle finish. Instead, stain products are most frequently described. The publishers of *The Painters Magazine* received many enquiries on the subject of shingle stain between 1903 and 1908. The questions and their responses were reproduced in a 1909 text.

Creosote stain was considered the best protective treatment. It could be prepared from raw linseed oil, turpentine, coal tar, creosote oil and a variety of other ingredients including colouring agents and fire-retardants. Oil stains were considered less durable and lead and oil paints even less so. The use of stains continued to be recommended in trade literature throughout the first half of the 20th century. Oil stains provide a choice of colour and enhance the weathering characteristics (*Specification Data*). Further protection is afforded by adding creosote (Ramsey and Sleeper) or pentachlorophenol or zinc napthenate (Grondal).

The range of products available today for application on a wood shingle or shake roof is enormous. In their most general categories, they are:

- bleaching agents to create a uniform weathered effect
- natural finishes to prolong the natural colour
- semi-transparent stains to add colour without hiding the natural grain
- solid colour stains to conceal the grain without hiding the wood texture
- preservatives, creosote solutions, oil-borne preservatives and water-borne preservatives, clear, coloured or colourless, to resist decay and discourage the growth of fungi, moulds and other surface vegetation
- fire retardants, pressure impregnated, to meet building code roof covering requirements

Finishing Western Red Cedar Shingles and Shakes dealt in some depth with these various preparations.

9.0 FIELD PRACTICE

9.1 ESTIMATING

What information there is on the preparation of 18th- and 19th-century rough carpentry estimates, in particular those sections dealing with wood shingle work, comes largely from turn-of-the-century handbooks and guides produced for a variety of individuals, including carpenters, contractors, builders, etc. The various rules-of-thumb, short cuts and so on advocated by the authors are, in the absence of first hand accounts, the only indication of what techniques tradesmen were using for estimating their roofing materials.

9.2 BILL OF MATERIALS

Common to almost every estimate was a "bill of materials" – a breakdown of the components making up the job, properly described, with the required quantities and possibly unit prices. Roofing materials were generally arranged: timber items; roof boards; shingle laths; tilting fillets and shingles; hardware items; nails and screws and sheet metal items; flashing and ridge rolls.

Quantities for individual roofing materials were calculated using various roof measurements. Roof area, by far the most important, was obtained in generally two ways: precise actual measurement of roof areas (using drawings or taking on-site measurements); or applying a rule-of-thumb adjustment to known ground area measurements. Suggestions on how to calculate roof area are abundant.

Hicks' Builders' Guide devoted two chapters to the geometrical measurement of roofs. For suggestions on calculating the roof area of "hip and valley," octagon tower and other more complex roof shapes, the reader is referred to the chapter "Hip and Valley Roofs" (Hicks, pp. 26-37).

An alternative to precise actual measurement was a method of computation, based on known ground area. It could only be used on the simpler roof shapes.

> ... determine the ground area of the building, including the overhang of the eaves or cornices. To this area, in square feet, add the following percentage for the different roof pitches:
>
> One-eighth pitch
> (rises 3" in 12") ....3% of area
> One-sixth pitch
> (rises 4" in 12") ....5% of area
> Five-twenty-fourths pitch
> (rises 5" in 12") ....8% of area
> One-quarter pitch
> (rises 6" in 12") ....12% of area
> One-third pitch
> (rises 8" in 12") ....20% of area
> One-half pitch
> (rises 12" in 12") ....42% of area
> Five-eights pitch
> (rises 15" in 12") ....60% of area
> Three-quarter pitch
> (rises 18" in 12") ....80% of area
>
> Point off two places from the total, which is in square feet, to reduce this amount to "squares", or in other words, divide by 100 square feet (Grondal, p. 28).

Various methods for determining shingle lath or roof sheathing quantities are offered by the guides and handbooks. All, of course, depend on the roof area calculation described previously. Hicks, on the subject of spaced roof "sheeting" suggested:

> Roof sheeting or sheathing could be closed or open. In estimating sheeting for shingle roofs make no allowance for spreading the boards. Calculate the same as for close sheeting a roof, for what is gained in spreading the boards is generally lost in the cutting (Hicks, p. 7).

For closed or solid sheathing, the actual superficial area was calculated and then various allowances added on, depending on whether the boards were tongue and groove or shiplap, or whether they were laid horizontally or diagonally, or whether they were "tight" or "common" (Radford and Johnson; Kidder).

Although not made clear, it is suspected "common" sheathing referred to an unmatched board, surfaced one side, while "tight" sheathing referred to a matched board, surfaced four sides.

On the subject of shingle quantities, the various rules of thumb assumed an overall shingle width of four inches, a certain number of shingles per bundle and an estimate of the number of shingles required based on the exposure (Hicks; Mortimer; Walker; Grondal). Grondal suggested that every 100 linear feet of hips or valleys be counted as an extra square.

The industry quite early settled on a bundle size which at the most common exposure covered 25 square feet or when grouped in fours covered exactly one square or 100 square feet.

Many of the sources already quoted offered suggestions on the calculating of nails for shingling. Hicks made a number of interesting points:

> On small jobs old contractors who have learned to judge from experience usually arrive at the quantities of nails by guessing. The following table, however, may be found [useful] to many in estimating nails for various purposes. As wire nails are coming into general use, and are already extensively employed, the basis of estimating has been made on the number of wire nails to the pound. If cut nails are used add one-third to the amount:
>
> *Table for Estimating Nails*
>
> 1000 shingles require 3-1/2 pound 4d nails.
> 1000 lath require 6-1/2 pounds 3d nails.
> 1000 feet of beveled siding requires 18 pounds 6d nails.
> 1000 feet of sheeting requires 25 pounds 10d nails… (Hicks, p. 61).

The Canadian Contractors' Handbook and Estimator recognized a difference between ordinary shingles, (probably sawn) and split pine and stated:

> One thousand shingles laid four inches to the weather will require five pounds of shingle-nails to fasten them on. Six pounds of fourpenny nail will lay one thousand split pine shingles (Mortimer, p. 120).

Later handbooks provided detailed tables for nail quantities based on nail size and exposure.

9.3 ESTIMATE OF COST

A document summarizing material costs, labour costs, profit and overhead and giving a final project cost was prepared for most projects. This cost estimate took many forms. In some cases material and labour costs were interspersed in one long tabulation. Such a format was followed by an estimate found among the *Lane Papers* (1835-75). The entries dealing with roof elements read:

	£	s	d
363 boards for sarking the roof	8	3	5
For joining, and grooving and nailing the sarking	3	"	"
16,000 shingles	16	"	"
For nailing on the shingles	4	"	"
For making scaffolding for the same	1	"	"

(Lane Papers).

In some estimates, material and labour were separated. Such a document was a tender submitted to Peter Russel in 1785. Under "Value of the Work" was the entry:

	£	s	d
13 square and a half of shingling at 18 per square Boarding included	12	3	0

(Rempel, p. 70).

Under "Value of Lumber" which follows is:

	£	s	d
13 ft. of Refuse Boards at 6/per 100 ft.	3	18	0
6000 shingles at 40/per 1000	12	0	0

(Rempel, p. 70).

Various figures were supplied in handbooks and guides for the rates of laying sheathing and shingles. Carpenters were expected to lay from 1500 to 3000 shingles per day, depending on experience and roof shape (Hicks; Mortimer; Kidder; Walker; Dingman).

9.4 SELECTING THE SHINGLES

The most commonly considered factors in the choice of a wood shingle or shake product have always been availability, durability and cost. The question of availability was usually the first considered by the mechanic. Prior to the opening of large scale mills on the west coast of the United States and Canada in the 1880s and the mass marketing of the red cedar or redwood product, shingle making was a very localized activity. The shingle produced by a particular shingle maker would depend to a great degree on:

- the species of tree most easily split, that could be obtained locally
- the grade of log which could be obtained
- the tools or equipment of the maker
- local custom or preferences.

The choice of shingle in this period, whether by the owner of the building or the mechanic installing the shingles, was severely limited by the locally available product.

With respect to durability, various claims have been made for a particular shingle depending on the species of wood or how it was made:

> The following table exhibits the average durability of shingles in exposed situations:
>
> Rifted pine shingles, from 20 to 35 years.
> Sawed, clear from sap, from 16 to 22 years.
> Sawed, clear with sap, from 4 to 7 years.
> Cedar shingles from 12 to 18 years.
> Spruce shingles from 7 to 11 years.
>
> Note: By soaking shingles in lime-water, their durability is considerably increased (Plumer, p. 16).
>
> • • • •
>
> White cedar shingles are the best in use; and when of good quality will last 40 or 50 years in our Northern States.... All shingles wear quite thin in time by rain and exposure. In warm damp climates they all decay within 6 to 12 years (Trautwine, p. 429).
>
> • • • •
>
> In 1879 a Mr. A.W. Spalding sent out questionnaires to 83 "competent" builders in the Western United States to evaluate the wear and tear on a particular list of building materials. On the frame dwelling, brick dwelling, frame store and brick store structures looked at, the shingles had in each case an average life of 16 years, with 6 per cent of depreciation per annum (Mortimer, p. 62).
>
> • • • •
>
> Good wood shingles are a thing of the past. The machine-made shingles of today are a very poor substitute and not to be compared to the old shaved shingles. The present shingles are cut from very inferior timber, and the wood fibre is so furred or thrown up in sawing that it absorbs moisture readily and retains it tenaciously, soon rotting them out.... The best of wooden shingles will shrink, leaving crevices and increasing a hundred fold the chances of leaks, besides only lasting a few years, as they are at present being made (Metallic Roofing Co., p. 18).

More recent shingle literature on the subject of durability made various claims for red cedar:

> ...shingles last for exceeding long periods of time on steep roofs (many instances are on record where 16-inch shingles have given good service for 75 years).... (Grondal, p. 28).

The same book made a quite specific claim for the No. 1 Blue Label 16 in. product:

> These shingles are of a superior grade for side walls on fine houses. On steep roofs (one-third pitch or steeper) they can be expected to have a life of more than thirty-five years under average climatic conditions; on one-fourth pitch roofs a life of at least 25 years can be anticipated. On side walls they will have an indefinite life usually greater than the useful life of the structure (Grondal, p. 18).

No corresponding statistics are provided for the red label and black label products. Current information on the durability of shakes and shingles relates quality to "rigid standards of in-plant inspections of the Cedar Shake and Shingle Bureau." These products are now subject to government regulation in both the United States and Canada (see U.B.C. Standards 32-B, 32-11 and C.S.A. 01181.1) No claims are made as to their estimated lifespan on a structure:

> Shingles and Shakes produced from Western Red Cedar (*Thuja Plicata*) have long been the premier wood roofing material of North America. The majority of cedar roofs remain untreated and are known to provide excellent service (*Cedar Shake and Shingle Bureau Design and Application Manual for New Roof Construction*, ca. 1992).

Statistics have not been located for modern shakes.

The relative cost of various shingles, while an important consideration to the owner or mechanic, is infrequently discussed by writers. A comparison of the cost of random width and dimension shingles was made in a 1904 text:

> Shingles cost from $3.00 to $5.00 per thousand, according to material and grade. Dimension shingles those cut to a uniform width if of prime cedar, shaved, 1/2 inch thich at the butt and 1/16 inch at the top, will cost $9.00 to $10.00 per thousand.... (International Textbook Co., No. 14, pp. 19-28).

Far easier to obtain are references to the cost of a particular shingle in a particular period. However, the range of material being considered makes comparison difficult. Costs in 1979 for an 18 in. x 3/4 in. to 1 1/4 in. handsplit and resawn shake were 17.95/bdl or 84.00/sq [5 blds/sq] and for an 18 in. No. 1 Blue Label shingle are 24.00/bdl or 89.95/sq. [4 blds/sq.]. The costs to cover a square, although not far apart, slightly favour the shake product.

9.5 ACQUISITION AND STORAGE

The comments of Grondal on the storage of red cedar shingles are applicable to almost any type of shingle:

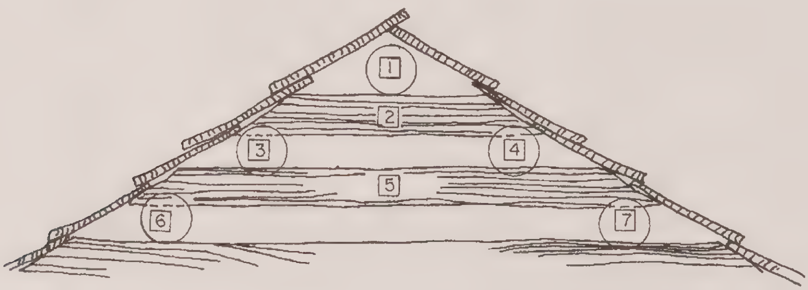
> When CERTIGRADE shingles are applied on a side wall or roof, they should be at a reasonably uniform moisture content. Therefore, if they are piled out in the open, a platform should be provided, so that the first layer of bundles will not be in contact with the ground, to prevent the undue absorption of moisture. Boards should be used to cover the top of the pile to keep out rain and to prevent over-drying of the bundles in the top layers in the broiling heat of the sun, so that *all* of the bundles in the pile will reach the same moisture content (Grondal, p. 15).

9.6 SELECTING A ROOF DECK

9.6.1 "Gable and Purlin Log"

A roof framing method employed on smaller gable-roofed log structures is the gable and purlin log roof. Poles were run the length of the structure, from gable end to gable end and regularly spaced to accept shingles or shakes. A blacksmith shop roofed in this manner was recorded in *The Foxfire Book*, 1972.

A somewhat similar roof was described in *Building with Logs*. The roof logs or purlins running parallel to the eave



CUT ROUND NOTCHES IN TOPS OF LOGS. THUS: NOTCH TOP OF # 2 TO HOLD #1; NOTCH TOPS OF #3 AND #4 TO HOLD #2; NOTCH TOP OF #5 TO HOLD #3 AND #4; AND SO ON. #2, #5 ETC. ARE GABLE LOGS; #1, #3, #4, #6, #7, ETC. ARE POLES RUNNING THE LENGTH OF THE BUILDING AND ACTING AS BOTH RAFTERS AND LATHING.

(Wigginton, *p. 96)*

line are spaced approximately at 24 in. intervals to take 30 in. to 36 in. long shakes. The shakes are "laid on the purlins in single courses, lapping the sides 1½ to 2 inches and overlapping the ends at least 6 inches" (Fickes and Groben, p. 23).

Clearly, a relationship exists between the spacing of purlins and the length of shingle. It is suspected that the length of shingle produced locally was the determining factor in purlin spacing.

9.6.2 Rafters and Shingle Lath

A method of laying shingles referred to frequently by writers of technical texts is a system of narrow boards referred to as "shingle laths," laid parallel to the eaves and across the rafters, to which the shingles are nailed.

Writing generally of the 19th and early 20th centuries, Edwin Guillet and the author of *The Foxfire Book* provided these descriptions of the shingle lath method:

> Pole rafters of split cedar, four inches wide, were laid a foot or so apart lengthwise across the rafters, and to these the shingles were fastened by wooden pins, each row overlapping the previous one. Barn shingles were often four feet long and placed on round rafters in constructing the roofs of the large cedar-log barns which may still be seen in various parts of Ontario. When eighteen-inch shingles came to be used, they were often nailed to strips of lath laid a few inches apart across the rafters, in place of sheeting, for this allowed circulation of air and kept the shingles dry underneath, delaying the process of rotting (Guillet, p. 6).
>
> • • • •
>
> If no sawmill existed in the area, one to two-inch thick lathing was split out of oak by hand and nailed across the rafters on two-foot centers, leaving sixteen to eighteen inches between each board. It was spaced in this manner to prevent the inescapable waste of wood that would have resulted from splitting out enough planks by hand to cover an entire roof (Wigginton, p. 97).

One of the earliest detailed descriptions of the shingle lath method of roofing was provided by John C. Trautwine in his *Civil Engineers Pocket-Book*:

> They [white cedar shingles] are nailed to sawed shingling-laths of oak or yellow pine: about 16 ft. long; 2½ ins wide, and 1 inch thick; placed in horizontal rows about 8½ in. apart. These are nailed to the rafters or purlins; which, for laths of the foregoing size, should not be more than 2 ft. apart from center to center (Trautwine, p. 429).

Handmade Shingles. Carey House, Witless Bay, NF

Early 20th-century texts such as the International Library of Technology series gave some prominence to the method. The comment on its superiority when compared with a solid deck are typical of the comments made by many writers:

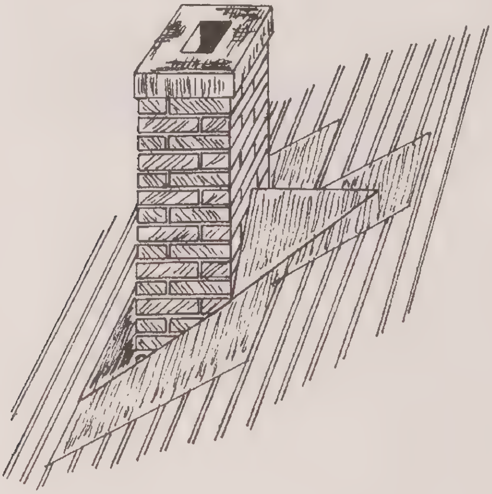
> The first method [on shingle lath] is, no doubt, the best, though generally used only on cheap buildings. In more expensive houses, the requirements usually call for a matched-board roof, which prevents the free passage of air [under the shingles] and causes the shingles to rot (No. 33B, pp. 56, 27).

The shingle lath on which shingles are laid are according to the same text usually 1¼ in. x 2 in. to 1¼ in. x 3 in. The description of the shingle lath installation included mention of extra boarding at eave, valley, chimneys, etc.

Radford's Cyclopedia of Construction also published in 1909 provided a sample estimate for a house in Long Island, N.Y. Under the head "Roof" was the entry:

> The upper slope of roof to be covered with 1 by 2-inch spruce shingle lath laid 5 inches on centers, all well nailed to rafters.
>
> • • • •
>
> Form valleys with 1 by 8-inch spruce or North Carolina pine valley boards. Cover all roofs to be shingled with first-quality 18-inch random-width Washington red cedar shingles, laid 5 inches to the weather, nailed with 4-penny galvanized nails (Radford and Johnson, p. 210).

Later references to shingle lathing do not differ substantially from those already quoted.



Around all chimneys, ventilators, skylights, etc., board the roof to the first rafter on each side; and at the back of the chimneys build into a saddle... nail the boards... at each side and at the front.
(International Library of Technology, No. 31, p. 13.27)

For the shingler the critical factors in shingle lath design were: the size of lath, which had to provide adequate support for the shingles over the space between rafters and the spacing of the lath which permitted regular fixing of the shingles.

There are few recent references to the shingle lath method. One suspects it gradually gave way to spaced sheathing, the next method discussed.

9.6.3 Spaced Sheathing

Between the shingle lath method of roofing just discussed and solid sheathing is a method of roofing called variously spaced sheathing, open sheathing or spread sheathing. For the purposes of this article, it is differentiated from the shingle lath method by the width of the gap between individual members. To qualify as spaced sheathing, the gap should not exceed the width of the member itself.

One of the first references to the spacing of sheathing was provided by the International Library of Technology, No. 31, 1903. Although quite vague on the size of the roof sheathing members and their exact space, it gave the current opinions on its value:

> The *second* method of laying shingles [the first being "on shingle lath"] is that of laying them on boards, which cover the entire surface of the roof. The boards should not be set close together, as they would then prevent the passage of air, stop ventilation, and cause the shingles to rot. This process of rotting arises from the warm air of the rooms below condensing when it comes in contact with the roof, making it wet, or resulting in what is called "sweating." It is also caused by capillary attraction acting through the butt ends of the shingles (No. 31, p. 13.32).

The roof system recommended by the Shingle Manufacturers' Association of British Columbia in 1921 was more specific in its description:

> For roofs use sized 2 x 4's or 2 x 6's for rafters, spaced not over 2 ft. centres and properly spiked and braced. For Roof Board or Sheathing use SIS L [surfaced or dressed one side] strips 1 x 4 or random widths to not more than 8 in. spaced not more than 2 in. apart and nailed solid (*Specification Data*, p. 53).

Later references to spaced sheathing are numerous. Current shingle specification guides continue to describe a spaced sheathing installation. A more or less typical description, in this case written for shakes, states:

> Red Cedar handsplit shakes may be applied over spaced or solid sheathing or existing wood shingle roofs. When spaced sheathing is used 1 in. x 4 in. (or wider) boards shall be spaced on centres equal to the weather exposure at which the shakes are to be laid, but never more than 10 in.... In areas where wind-driven snow conditions prevail, roofing felt interlays should be used or a solid-roof deck specified (Council of Forest Industries of British Columbia, p. 1).

9.6.4 Solid Sheathing

Despite the warnings of texts, such as that stated in *Carpentry Craft Problems*, "...spreading the sheathing provides ventilation for the shingle. Without this ventilation many wood-shingled roofs would rot, especially in wet climates and during periods of much rainfall" (Siegele, p. 206.), solid sheathing came to be used with increased frequency.

A specification for laying red cedar shingles provided by the Shingle Manufacturers' Association of British Columbia is one of the earliest references found which actually recommended a solid sheathing installation:

> Use shiplap solid instead of 1 x 4 strips where building paper insulation is used (*Specification Data,* p. 53).

Building paper was at the time coming into general use both on roofs and sidewalls for what was being advertised as "extra warmth," but what was in fact efficient only in reducing drafts. The first forms of building paper were rosin sized kraft paper or similar products which "breathed" and did not act as condensers.

A complete discussion of solid sheathing, its merits when used with certain roofing materials and the reason for its adoption for certain shingle installations was provided by the *Certigrade Handbook of Red Cedar Shingles*:

> The choice of open or solid sheathing for the roof deck is optional when CERTIGRADE shingles are applied to roofs. If a solid roof deck is preferred, either matched or unmatched one-inch boards, shiplap, or softwood plywood graded and applied according to specifications of the American Plywood Association under the applicable Commercial Standard, may be used. When "composition" roofing in either roll or "shingle" form, of the pliable, saturated type is applied on a roof, a solid roof deck of *matched* lumber is demanded, for material of this kind acts as a condenser when weather conditions change rapidly, with a resultant accumulation of condensed water that may drip through the roof deck and ruin the ceilings. Many carpenters and contractors have wasted much time looking for mysterious leaks in such roofs, when in reality the trouble was due to the inability of the roof deck below to act as a tight roof and carry the condensed water down to the eaves *under* the condensing layer (Grondal, p. 31).

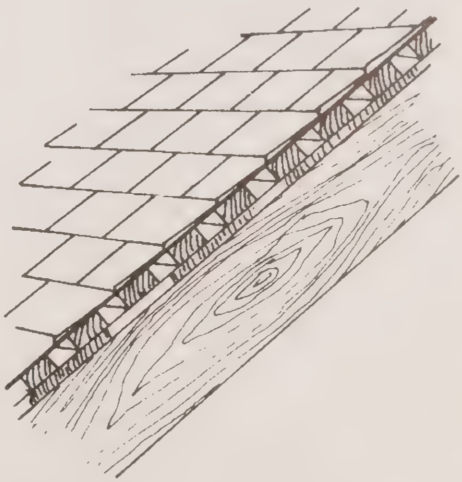
Modern guide specifications make little differentiation between spaced or solid sheathing. It is doubtful if this move to solid sheathing has been made without some sacrifice in shingle durability.

9.6.5 Combination

A third method of laying shingles on a rafter roof is a combination of the solid deck and shingle lath methods previously discussed. One source, the International Library of Technology text No. 33B dealt with it in some detail:

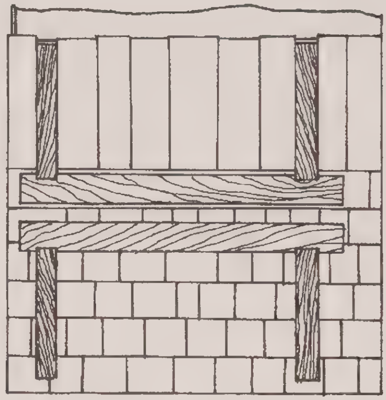
> The *third* method of laying shingles... is on matched boarding a. covered with roofing felt b. the lath c. is then nailed on, the same as in the first method, [the shingle lath method] and the shingles are laid on the lath.
>
> This method makes a very good roof, when the spaces between the ends of the lath are left open at the gables for ventilation; but when closed, as is usually the case, makes the poorest roof of all, as the closed air space only increases the condensation and hastens the destruction of the roof (No. 33B, pp. 13, 32-33).

That this method did not disappear entirely in later years is proven by an illustration included in *Materials and Methods of Architectural Construction*, 1962, labelled "Wood Shingles in Combination" which is similar to that described above (Parker, Gay and MacGuire, p. 198).



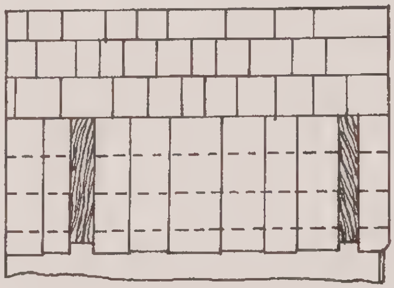
9.7 SCAFFOLDING

To place the starter courses and lower roof courses of shingles at the eave, some form of scaffolding was required at the perimeter of the building. One of the few writers to comment on this construction was H.H. Siegele:

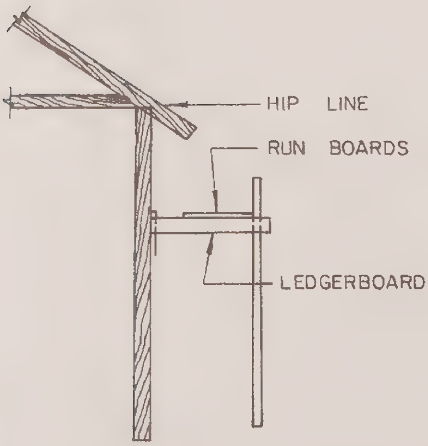


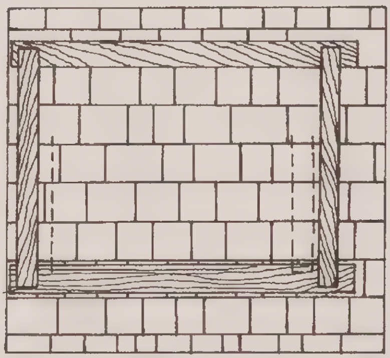
Scaffolding and Toe-Holts – [The first figure] shows the height of the scaffolding for shingling the eaves of a roof. We do not give the distance between the staging and the edge of the roof in figures, because that must be determined by the man or men who must work on the scaffold. We have indicated this by the line called "Hip Line" on the drawing.

That is to say, the ledger boards should be so placed that when the runboards are on, the hip line of the men working on the scaffold will be approximately where we show it. (If a short man and a tall man have to work together, of course, a compromise must be agreed upon.)

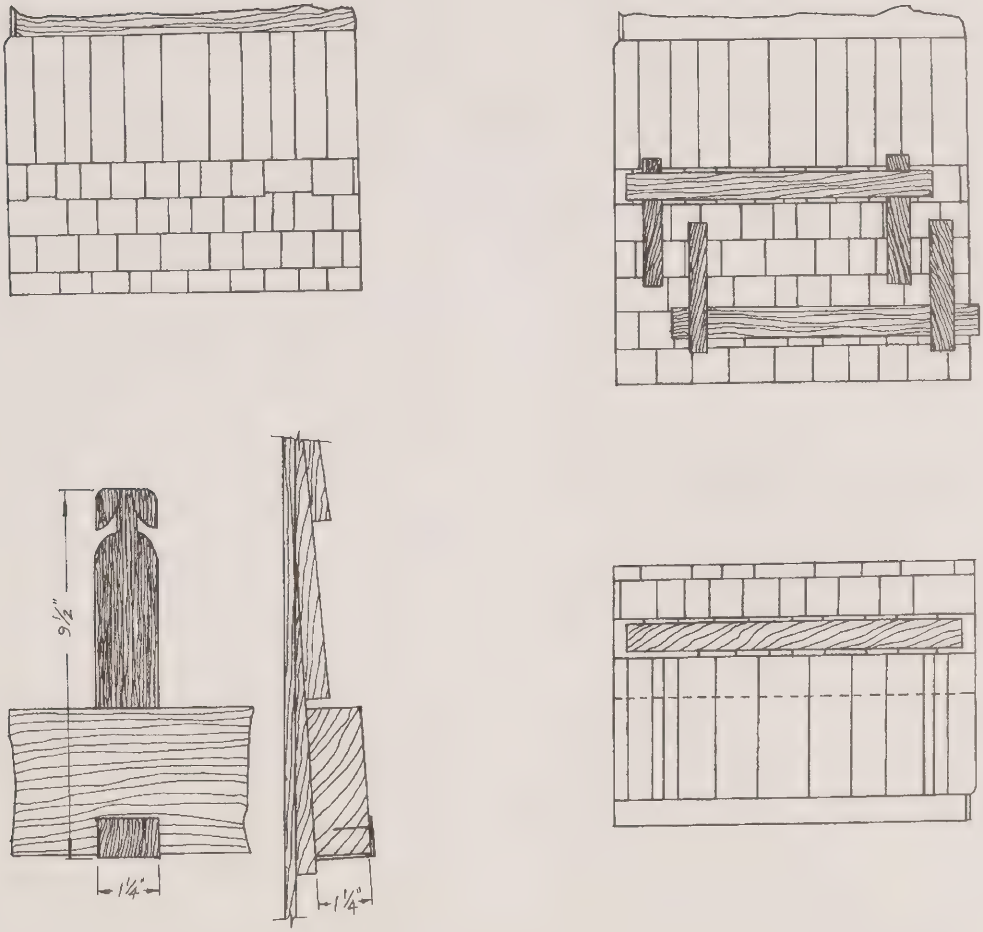


The practice of trying to finish the cornice and do the cornice shingling from the same height of scaffolding is a bad one. Nothing is gained either in time or in workmanship by it – in fact, good workmanship is impossible where this is done. The right way is to build the scaffold the proper height for shingling, and when the cornice has to be finished, it should be lowered to the right place for that. Bending over to finish the cornice or stretching to start the shingling are handicaps to the workman (Siegele, p. 211).





Toe Holts (after Siegele, p. 210)



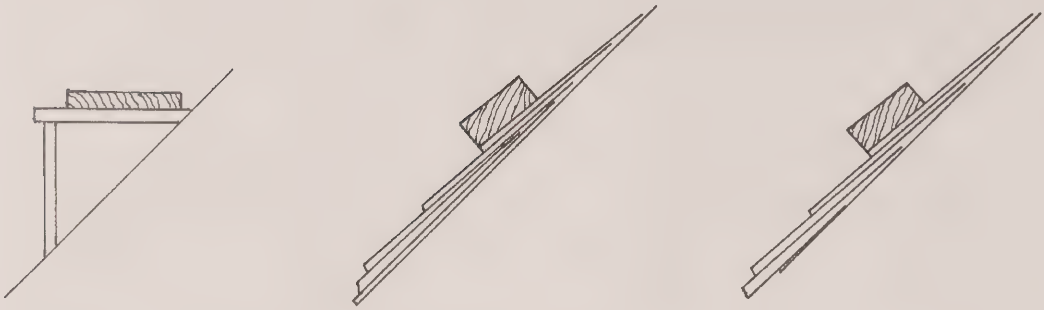
Toe Holts (after Siegele, p. 210)

9.8 TOE-HOLTS AND SHINGLING STOOL

With the work of the lower roof complete and given adequate working room, the shingler worked his way up the slope using some form of moveable scaffolding. Siegele in 1942 described a number of toe-holt types and their fastening. The 2 x 4 cross member which provides a foothold is attached using shingles, wire ties or a specially designed hook. These ties can be cut or removed and the 2 x 4 relocated, or extensions added.

Included in Siegele's description of "toe-holts" is a description of another piece of apparatus used by the shingler, a shingling "stool:"

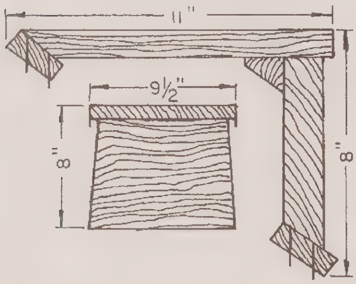
> Shingling Stool – [The figure shows] a section of a shingling stool with toe-nails that will not let the stool slip. The small detail shows the end view of the stool. These details together with figures given are sufficient to aid the carpenter in making such a tool (Siegele, p. 212).



Old-fashioned Toe-holt – Brackets nailed on the roof with plank on them.

Common Toe-holt

Simple Iron Bracket Toe-holt



Shingling Stool (after Siegele, p. 212)

Three designs for "toe-holts" were given by *Radford's Cyclopedia of Construction*, 1909. The second has some similarities with those discussed by Siegele.

9.9 LAYING THE EAVE PROTECTION AND UNDERLAYMENT

No early descriptions of laying a building felt or paper as an eave protection have been located. Current practice on how and where a particular material should be laid is documented in numerous wood shingle and building material trade publications. The standards for eave protection given by the National Building Code are a close reflection of these recommendations:

> 9.27.5.1. Except as provided in Article 9.27.5.3., eave protection shall be provided on shingle, shake or tile roofs, extending from the edge of the roof a minimum distance of 914 mm up the roof slope to a line not less than 300 mm inside the inner face of the exterior wall.
> 9.27.5.2. Eave protection shall consist of not less than 0.15 mm polyethylene laid as a continuous sheet without the use of cement, or No. 15 asphalt-saturated felt laid in two plies lapped 480 mm and cemented together with lap cement, or 45-lb roll roofing. Roll roofing shall be laid with not less than 100 mm head and end laps cemented together with lap cement.
> 9.27.5.3. Eave protection is not required over unheated garages, carports and porches, or where the roof overhang exceeds 900 mm measured along the roof slope from the edge of the roof to the inner face of the exterior wall, or where shingles for low slope roofs are used (NRC, p. 319).

Early references to underlayment of an entire shingle roof with building paper or felt are surprisingly numerous. The nature of the material, whether a tarred paper, tarred felt or waterproof paper, is specified, as well as the number of layers or "plies" required. Details on head and end lap and the method of fastening are not supplied.

For each writer advocating an underlayment there is another cautioning against its use. The reason frequently given for not using underlayment is its interference with the free passage

of air needed to ventilate properly the underside of the shingles. A method of laying shingles with an underlayment which overcomes this most frequently raised objection, was put forward by the International Library of Technology, No. 33B, 1909, given under 4.45, Combination.

Current standards for underlayment of a wood shingle roof, given by the National Building Code, generally reflect the materials and methods of installation advocated by shingle manufacturers and employed in the field:

> 9.27.6.2. When used with shingles, underlay shall be installed parallel to the eaves with head and end lap of not less than 50 mm. The top edge of each strip shall be fastened with sufficient roofing nails to hold it in place until the shingles are applied. The underlay shall overlap the eave protection by not less than 100 mm. (See article 9.27.10.2 for underlay beneath wood shakes) (NRC, p. 319).

It is not certain when it was first recognized that an underlay of some form was almost always required for a wood shake installation. Almost all contemporary literature calls for an interlay of felt between shake courses:

> After each course of shakes is applied, an 18-inch wide strip of 30-pound roofing felt should be applied over the top portion of the shakes and extending onto the sheathing, with the bottom edge of the felt positioned at a distance above the butt equal to twice the weather exposure.... Further, the use of roofing felt interlay between courses is not necessary when straight-split or tapersplit shakes are applied in snow-free areas at weather exposures less than one-third the total shake length (3-ply roof) [D.H. Clark, p. 21].

Some writers suggest a different weight felt for differing situations; such as a 15 lb. (No. 15) felt in relatively snow-free areas and a 25 lb. (No. 25) felt for general use.

A special protection for hips and ridges is now called for on most shake roof installations.

No early references on the use of felts in this situation have yet been discovered. As a part of the underlayment treatment, it bears no relationship to hip and ridge flashing procedures.

9.10 INSTALLING THE FLASHINGS

9.10.1 Open Valleys

The earliest detailed description of flashing by a North American author was by T.M. Clark, 1886. Under the head, "Flashings" were good descriptions of valley, hip, ridge, wall and chimney conditions. Although written expressly for a slate finish, it is clear from a sample specification provided later in the text, that the descriptions apply equally to a wood shingle finish.

The first method of flashing a valley described by Clark would give an open valley:

> The valleys are covered with a long strip of zinc, fifteen or sixteen inches wide, laid the whole length of the angle, and soldered together at the joints.... This is tacked at the edges, and the slates [or shingles] laid so as to lap over it on each side. If the metal were not subject to expansion by heat, this would perhaps be the best way; but the long strips lengthen very sensibly under a summer's sun, only to contract again in winter, and the ultimate effect often is to tear them at same point, making a bad leak (T.M. Clark, p. 79).

Because the expansion and contraction of zinc is greater than that of any other common metal, it is easy to understand Clark's reluctance to recommend this method of flashing. Hicks, writing in 1894, while not labelling it the best way to flash a valley, did admit that the open valley flashing method was commonly used:

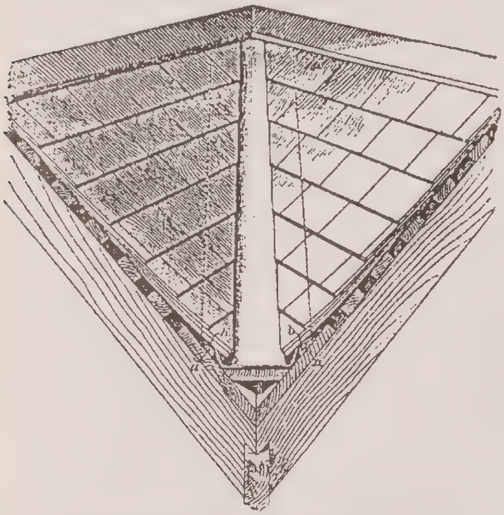
> The usual custom is to put in a strip of 14-inch tin for the valley...no nails should be driven through the valley tin except near the outer edge as a nail hole will frequently cause a leak by water getting under the shingles (Hicks, pp. 78, 79).

A much wider open valley flashing is described in International Library of Technology, No. 30:

> The valley, therefore, acts in the capacity of a gutter, and is flashed accordingly. The tin is joined, generally at the ends, to form a continuous gutter in the depression, and its edges are turned up under the shingles about 6 inches. The shingling is not carried

> down to the intersection of the slopes, but is stopped about 5 inches from the valley rafter, and the gutter, thereby, is left open (No. 30, p. 9.94).

An open valley described in the International Library of Technology, No. 31 described a similar flashing but with some changes: the valley lining or flashing is formed over tilting fillets placed along both sides of the valleys and the suggestion was made that lining should extend under the shingles 3 or 4 inches. Unfortunately no dimension was provided for the distance between the angle of the valley and of a fillet. The width of metal required is not therefore known. A 1962 description of an open flashing was very close to that of 1903. It called for large pieces of copper, soldered to form a strip 18 to 20 inches (No. 31, p. 13.28). The tilting fillets (a) and the part of the valley lining which extends under the shingles (b) are shown in the illustration.



Open Valley Flashing (International Library of Technology.)

One of the most careful designs for an open valley flashing was provided by the *Cedar Shake and Shingle Bureau Design and Application Manual for New Roof Construction*, 1964. It is the only source to have considered adequatelythe effects of roof pitch on the design of the flashing. It recommended extending the flashing three or four inches further up the lesser slope, and keeping the shingles further back from the centerline, or providing a centre crimp.

The *Certigrade Handbook of Red Cedar Shingles* was one of the first sources to recommend against the use of "closed valleys" for shingle roofs altogether. An open valley for a "shake" [extra thick shingle] was described in some detail by the *Certi-Split Manual of Handsplit Red Cedar Shakes.*

A "shingle in" or "step fashion" technique for laying the valley metal is now regularly specified for shakes.

9.10.2 Closed Valleys

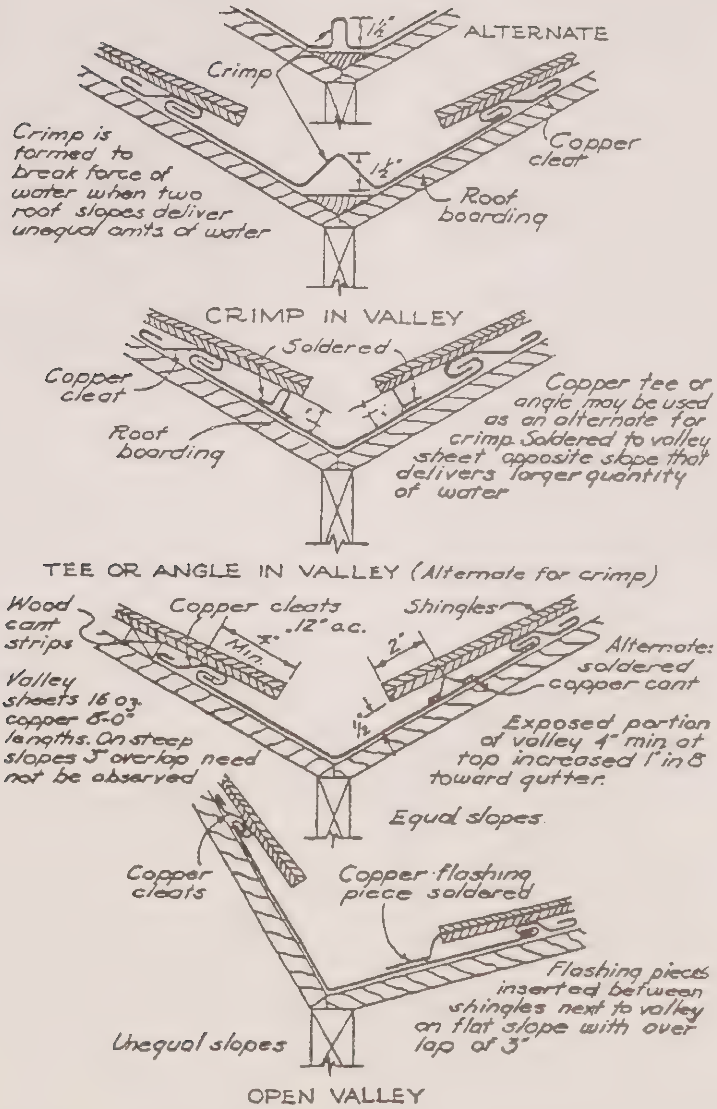
T.M. Clark, while describing an open valley flashing treatment, also discussed a rival method, giving a closed valley appearance:

> ...a sufficient number of trapezoidal pieces of zinc or other metal are cut out ... in length equal to one of the slates [or shingles] used, and in width varying from about ten inches at one end to fifteen or more at the other, according to the pitch of the roof. These pieces are taken on the roof by the slater [or shingler] and "slated in", [or shingled in], each forming a part of the two courses of slate [or shingle] corresponding on each side of the angle ... and each being laid over the course of slates [or shingles] next below it, while the slates [or shingles] themselves are laid more closely into the angle of the valley than when the other system [open valley] is employed. Although more metal is used in this way, the labour is less, and the work on the whole more satisfactory, because more permanent (T.M. Clark, p. 80).

Clark ended his discussion of flashings by recommending the flashing method to use in each situation. In the case of valleys, his preference was clearly for a "shingling in" method. I.P. Hicks, writing in 1894, drew a similar conclusion. His design, not as fully described, involved some special cutting of the lower edge of the flashing pieces:

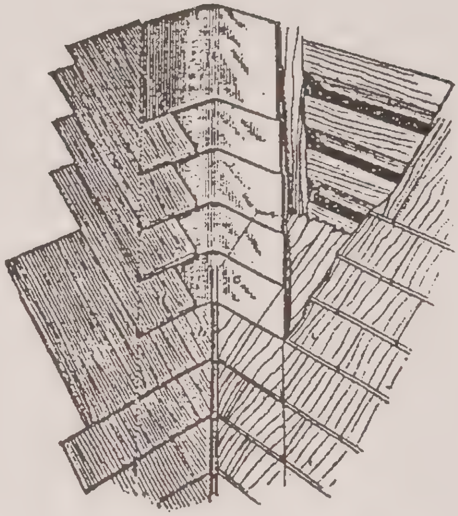
> The best way to shingle a valley is to use single sheets of tin 10 x 14 inches, under each of the courses of shingles, leaving only about 1/4 inch of the tin exposed below the butts of the shingles.... To increase the durability of the valley, paint tin flashings before laying (Hicks, p. 79).

International Library of Technology, No. 31, 1903, instructed on the construction of "closed" valleys. It is the only source to have acknowledged that square pieces of flashing could be used:



A variety of open flashing details, recommended by the Copper and Brass Association in Architectural Graphic Standards *are illustrated. (Ramsey and Sleeper, p. 201). Various methods of blocking out and breaking the force of water at the base of the valley are exhibited.*

> ...the shingles are interwoven with metal sheets.... The shape of this sheet flashing will vary with the pitch of the roof, if it is desired to make the lower edges of the sheets parallel with the butts; but this is not necessary, as square sheets will serve the same purpose, provided they are properly lapped (No. 31, p. 13.28).



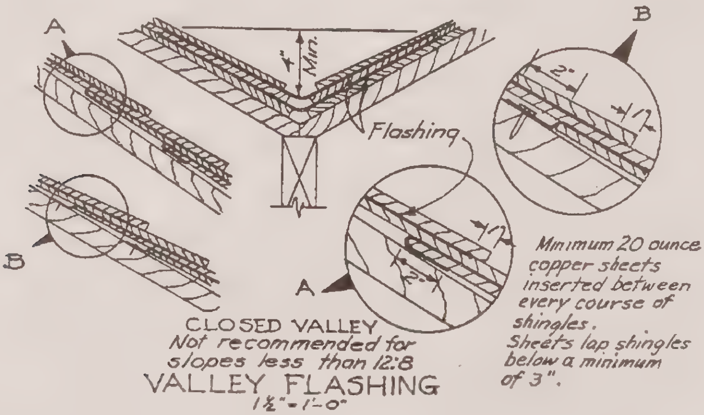
Shingles Interwoven with Metal Sheets

A 1962 description of "closed valleys," suggested one size of sheet metal be used and gave a minimum lap length:

> Closed valleys are formed by laying the shingles...close together and inserting under each course trapezoidal pieces of copper, 15 x 10 x 9 in., overlapping each other at least 3 in. Closed valleys have a better appearance than open valleys but are more difficult to make tight (Parker, Gay and MacGuire, p. 211).

Two methods of attaching "shingled in" valley flashings were offered by *Architectural Graphic Standards*. Rather than give a sheet width for the flashing, a flashing sufficient to hold water to a maximum four inch depth in the valley was called for.

While not recommending closed valleys, *The Certigrade Handbook of Red Cedar Shingles*, 1964 provided a sample specification clause for the flashing:



Two Methods of Attaching "Shingled In" Valley Flashing
(Ramsey and Sleeper, p. 210)

> Flashings for closed valleys shall be separate pieces so that there will be a flashing between each course of shingles. Each piece shall be set so as to lap at least 3 in. and to be entirely concealed by the shingles; shall be fastened with nails at the top edge only; shall be sufficient length to extend 2" above the top of each shingle and shall lap the flashing sheet below 3" (Grondal, p. 93).

A closed valley suitable for wood shakes was offered by the *Certi-Split Manual of Handsplit Red Cedar Shakes.*

> In closed valleys a 1" x 6" wood strip is nailed into the saddle and covered with roofing felt (30-pound).... Shakes in each course are edge trimmed to fit into the valley, then laid across the valley with an undercourse, of 18 to 24 gauge, pre-painted galvanized iron, which has a 2-inch headlap, and which extends 10 inches under the shakes on each side of the saddle (D.H. Clark, p. 23).

A 1975 specification guide provided by the Council of Forest Industries of British Columbia for shingle or shake closed valley installations suggested a head lap of 8 in. for the valley metal (COFI., p. 2).

9.10.3 Masonry Walls and Chimneys

On the matter of flashing generally, T.M. Clark allowed that basically two methods be followed: flashing with large strips or with small pieces. To illustrate the first method as applied to a wall he supplied the following description:

> The same method applied to flashing against a wall consists in covering the joint by a long strip, one edge of which is bent over, and tucked into a reglet, groove or "raggle" cut in the stone or brick work of the wall six inches or more above the slope of the roof, and parallel with it. The efficiency of this depends on the care with which it is done. The effect of alternate heat and cold on such a flashing is to warp it until it springs out from the "raggle" either at one end or in the middle, letting a stream of water run down into the rooms below...and this can only be prevented by cutting the groove quite deep, an inch or so, instead of the half-inch which is common, turning in the flashing to the very bottom of the groove, and wedging it firmly in with slate chips and cement. The wooden chips generally used for the purpose soon shrink and become loose (T.M. Clark, p. 79).

Describing the second method, using small pieces, as applied to both walls and chimneys, he stated:

> In its application to the flashing of walls and chimneys there is less to be said in favor of it, compared with a first-class job in the other style. In the "stepped flashing" as it is called, composed of small pieces, no groove is cut in the masonry, but short lengths of the horizontal mortar joints are raked out, and pieces of metal are cemented in, one above another, lapping over each other like a flight of steps. This is much more permanent than a single strip, especially if the pieces, instead of being inserted in a raked-out joint, are built into the masonry itself, as is often done; but in exposed situations the wind and rain are likely to blow into the vertical crevices which are left between the masonry and the metal when this is folded down against it, so that elastic cement, or a stopping of "paint skins" and fine sand are necessary to make them tight (T.M. Clark, p. 80).

Having described both methods, Clark concluded by selecting the long flashing method; one of the reasons offered was the better connection it makes with rough stone-work:

> The stone-work is in places so rough that it would be impossible to turn down a sheet of stepped flashing against it so closely as to be tight, and the other mode seems preferable, but we enjoin upon the roofer the greatest care in securing the strips into the grooves (T.M. Clark, p. 80-81).

As for the actual detail to be employed for a chimney or wall application, Clark clearly favoured a base and cap flashing design:

> As for the metal of the flashings, we insist that those on walls and chimneys shall be "capped", and that the capping shall be of four-pound lead. All the rest we direct to be of No. 13 (sixteen-ounce) zinc....
>
> This capping is the best safeguard against the evil effects of expansion of long flashings, and consists in making them in a certain sense double; one strip of zinc covering the roof, [extending over the shingles], and being turned up against the masonry, almost to the line of the "raggle", or groove, with a few nails to keep it in place, while a second strip of lead, thin enough to be easily dressed close against the wall, is cemented into the "raggle" just above the upper edge

> of the zinc strip, and turned down over it, reaching to a line an inch above the surface of the roof, so that the two pieces of metal can expand and contract independently without finally opening a joint. It must not approach nearer than an inch; if it does, it may dip into a current of water or melted snow flowing down the roof, and the capillary attraction between the two metal surfaces will draw moisture up, and over the edge of the inner strip, to find its way into the rooms below (T.M. Clark, p. 81).

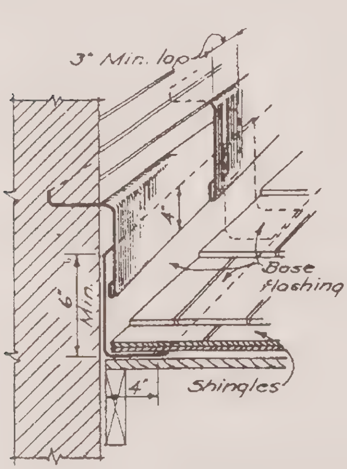
Although never stated as such by Clark, it is clear the capping of flashings applied equally to "shingled in" and stepped arrangements or long strips turned into reglets parallel with the roof slope. In a model specification included in Clark's book was a statement:

> Furnish wide counter-flashings of 4-lb. lead for the mason to build into joints of chimneys, shingle in wide zinc flashings to turn up against the brickwork as high as the counter-flashing will allow; then turn down the counter-flashing, dress close, and cement perfectly tight against the brickwork (T.M. Clark, p. 231).

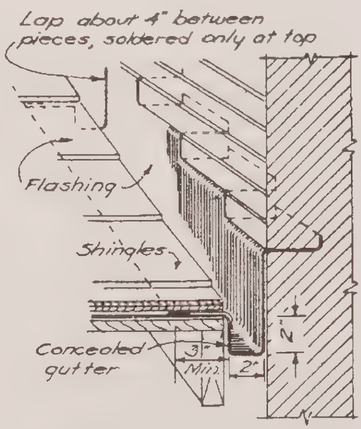
> Flashing against masonry, such as chimneys or walls, is done by laying pieces of copper, called base flashing, under the shingle, slate, or tile, and bending them up against the masonry. The pieces should extend at least 6 in. under the roofing and 9 in. up the face of the masonry. Another strip of copper or lead, called counter-flashing or cap flashing, is built into the masonry and turned down over the base flashing. By this method expansion is allowed for without reducing the watertight qualities of the flashing. Behind chimneys on pitched roofs crickets or saddles are built with sloping sides and covered with copper to prevent the lodging of snow (Parker, Gay and MacGuire, p. 211).

Architectural Graphic Standards provided details for stepped flashing against a wall, one piece and two pieces and three methods of flashing a chimney. Details for a one-piece and two-piece chimney cricket are also provided.

Master Specifications provided in the *Certigrade Handbook* for chimney flashings, agree almost completely with the Clark reference; the base flashings run up under the shingles 6 in.

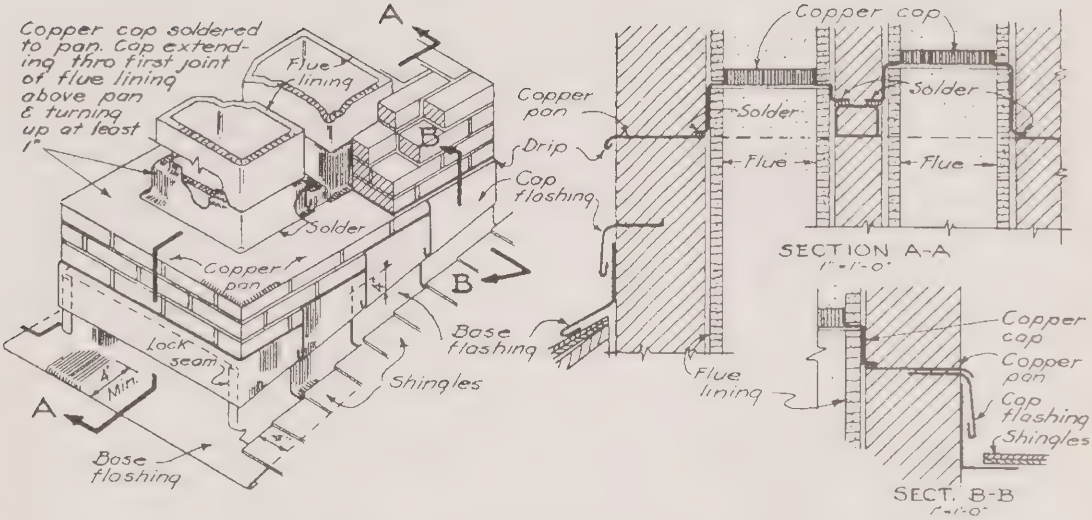


Stepped Flashing (Ramsey and Sleeper)

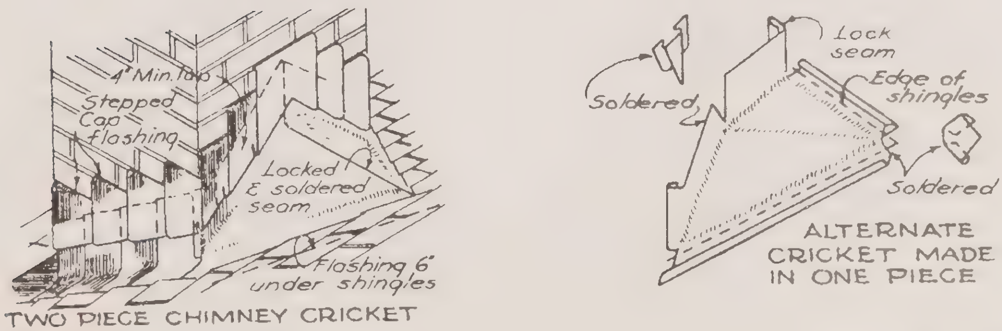


Stepped One-Piece Flashing (Ramsey and Sleeper)

A description of flashing against masonry, whether chimneys or walls, provided by Parker, Gay and MacGuire, is more or less representative of current practice. The base flashing extends under the shingles rather than over. A "cricket" is proposed for the area behind the chimney: minimum (eight inches being of course better, particularly on the upper side) and counter flashings extend to within one inch of the surface of the finished roof. The description of step flashing where vertical surfaces occur in connection with a slope, is more precise in its description than any earlier reference:



Pan type (p) thro wall flashing (p) type used generally except on steep roofs or where large area of brick is exposed between copper pan and lower cap flashing (Ramsey and Sleeper, p. 99)



Ramsey and Sleeper, p. 199

They shall be formed of separate pieces, shall turn up not less than 4" at any point, shall be built into the masonry, shall lap generally 3" but in no case less than 2", shall not be soldered, shall follow the joints of masonry and shall be installed in reglets cut into these joints (Grondal, p. 94).

9.10.4 Hip and Ridge

T.M. Clark identified two methods of flashing a hip, using large strips or using small pieces. Describing the first type, he stated:

> Hips are covered with strips by putting a wooden "hip roll" on the boarding and laying the slates [or shingles] close up to it, subsequently taking on the metal, fitting it closely around the roll, and letting it extend on each side three or four inches over the slates (T.M. Clark, p. 79).

Of the second method, Clark stated:

> The principle of subdivided flashings is applied to hips by slating [or shingling] in pieces of metal, the slates [or shingles] then being laid out to the very edge. This is both tighter and neater in appearance than the hip roll with its spreading sides (T.M. Clark, p. 80).

The International Library of Technology, No. 31, 1904, made comments on the shingled-in and roll methods:

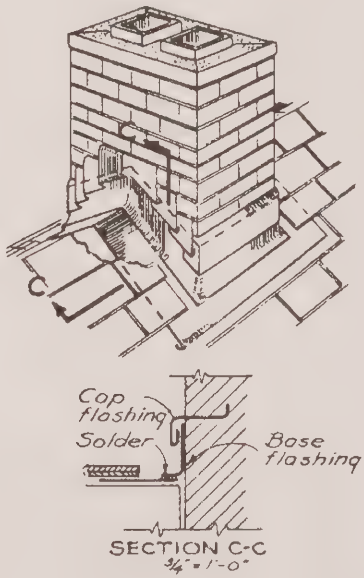
> While not prolonging the life of the shingles, this [the shingled-in method] no doubt makes the most weather-proof hip except a metal roll. The roll, however, never looks well, and on that account should be avoided (No. 31, p. 13.30).

On the subject of flashing a ridge, three methods were offered. Two involved a metal flashing:

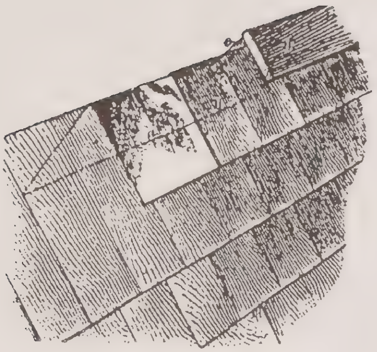
> [One method] consists of laying over the last row of shingles but one, a metal flashing... which extends on each side of the ridge to the depth of the last row, after which the last row of shingles may be laid and the ridge capped with a ridge saddle....
>
> [in another method] the wood roll [cap to the ridge pieces] is covered with a galvanized-iron or copper roll and wings pushed over it. Galvanized nails are driven into the roll, near the wings, to keep it in place; lead is also used for the same purpose (No.31, pp. 13.31-32).

A variety of hip and ridge flashing methods for shingle type roofs are illustrated in *Architectural Graphic Standards*.

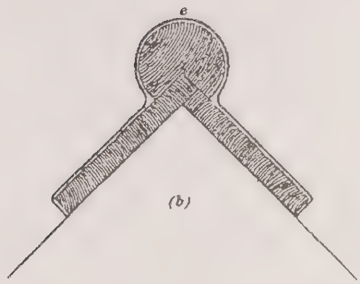
The *Certigrade Handbook of Red Cedar Shingles* was surprisingly conservative in its use of flashing metals on hips and ridges. The reasoning was that "the chance for leakage to occur with proper ridges is very slight" (Grondal, p. 36). A modified "Boston hip" construction of specially sorted and trimmed shingles was recommended for use in both hips and ridges. If a flashing were used the recommendation was that it extend "only for a distance of 3 inches on each side of the ridge" (Grondal, p. 36).



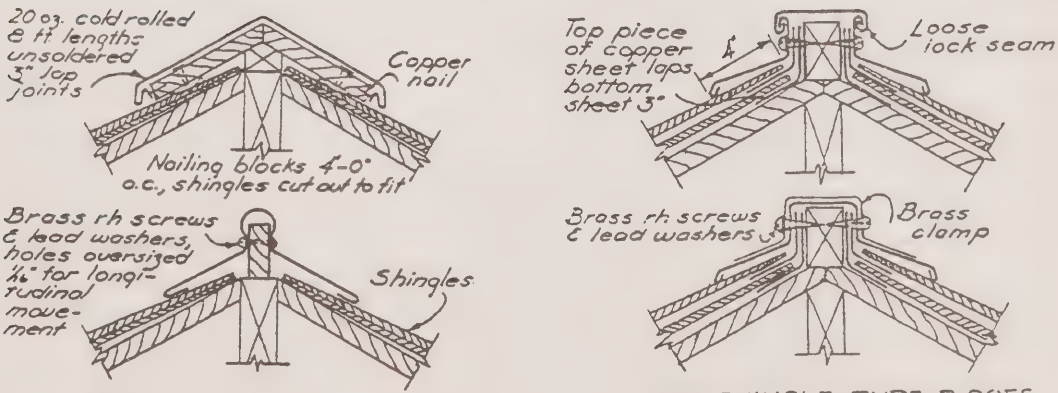
Flashing at Ridge



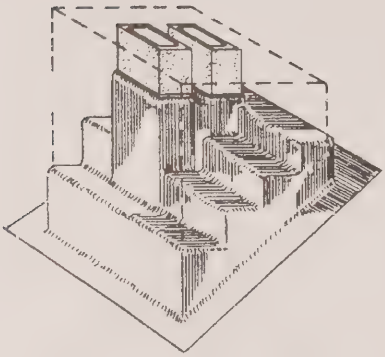
Laying over the last row of shingles but one, a metal flashing (International Textbook Co.)



A wood roll is covered with a galvanized – iron or copper roll and wings pulsed over it. (International Textbook Co.)



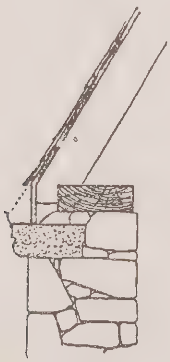
Variety of Hip and Ridge Flashing Methods (Ramsey and Sleeper, p. 201)



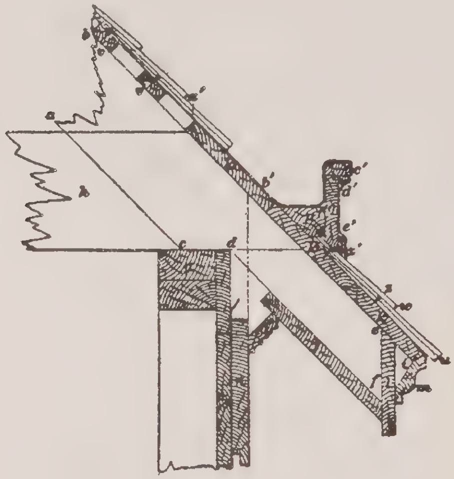
Stepped thro flashing type (S). This type of thro wall flashing used for steep roofs or where a large area of brick is exposed to the weather. In chimneys built of stone rubble or ashlar this type of flashing is especially recommended.

9.10.5 Gutters

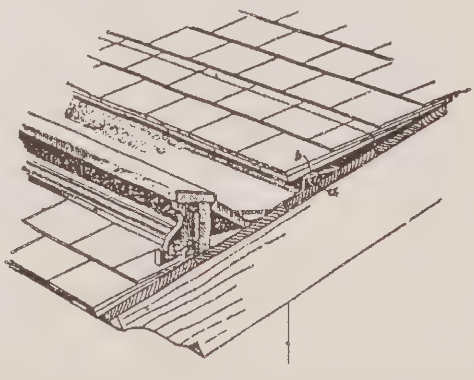
Most gutters fall into one of two main types: the built-in eave gutter and the stock wood or metal hanging eave gutter. Generally no flashing was specified for installation of the latter. In the case of the built-in eave gutter, however, the metal lining was extended under the wood shingles as a flashing. International Library of Technology No. 30 recommended the lining extend five to six inches under the shingles (p. 9.91). Text No. 31 by the same publisher illustrated a similar gutter but showed a tilting fillet along the upper edge just above the overflow. The lining they suggested "may with advantage extend several inches up under the shingles" (p. 13.28). *Architectural Graphic Standards*, in its description of tin roofing illustrated a "pole gutter" with a tin lining. The recommendation was that the lining pass over a cant strip 3 in. above the overflow line and extend under the shingles (Ramsey and Sleeper, p. 189).



Gutter



Built-in Eave Gutter
(International Textbook Co.)



Built-in Eave Gutter with Tilting Fillet (International Textbook Co.)

A rather special gutter, lying somewhere between a built-in gutter and ordinary stock iron gutter, was described by T.M. Clark, 1886. Quoting from specification he stated:

> ...gutters of No. 24 galvanized – iron as per detail drawing... running up 16 inches under slate [or shingles], and to have front edge turned over a 1/4 inch by 5/8 inch wrought-iron bar, with galvanized wrought-iron under slates [or shingles], and strip of four-pound lead one inch wide soldered or under side to cover edge of stone cornice".... (T.M. Clark, p. 82).

9.10.6 Other Locations

A set of flashings given scant attention in technical texts are those needed at the flanks of the dormer-windows and below the sill of the window. International Library of Technology, No. 30, gave a general description of such flashings:

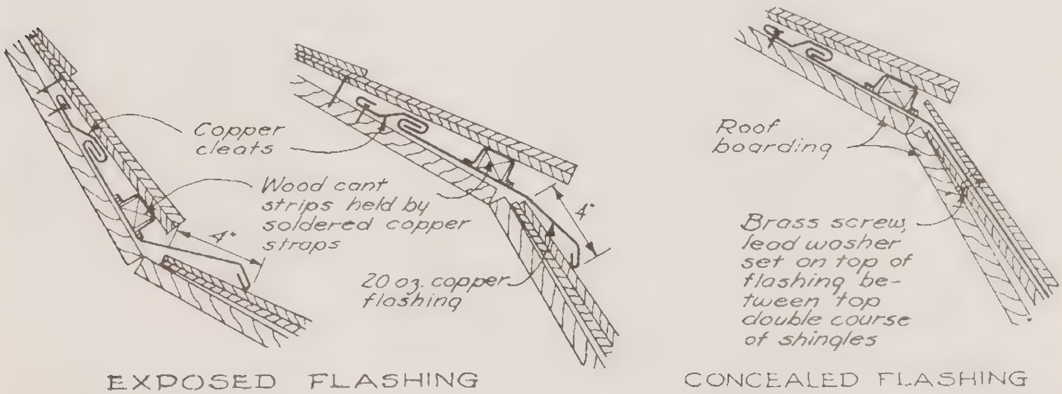
> Around skylights and dormer-windows, where the sill rests on the slope of the roof, flashing is applied so that it extends under the roof covering which is adjacent to the sill, and turns up and over the sill itself in such a manner as will prevent any possibility of water working its way between the sill and the slate or shingles. The sides of a dormer, where they intersect with the roof pitch, are flashed in the same manner as are the valleys, except that the shingling or other covering may be carried up close to the finished sides (No. 30, pp. 9.95-96).

Parker, Gay and MacGuire, writing many years later, changed much of the detailing. The flashing for the sill was carried over the first course of shingles rather than under. The flashing was carried under the sill rather than over. The description of flashing the sides of the dormer stated:

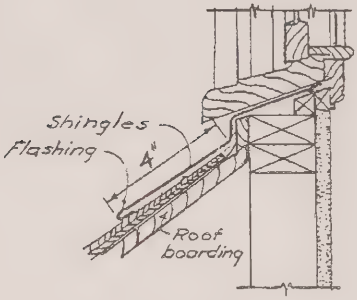
> Against dormer windows or any wood wall a piece of copper about 7 in. square is laid on the roof boarding under each course of shingles or slate, bent to a right angle, and extended up under the wood or slate siding on the dormer (Parker, Gay and MacGuire, p. 211).

Illustrations of flashing the window sill of a dormer, sometimes called an apron and the flanks were provided in *Architectural Graphic Standards* in 1956.

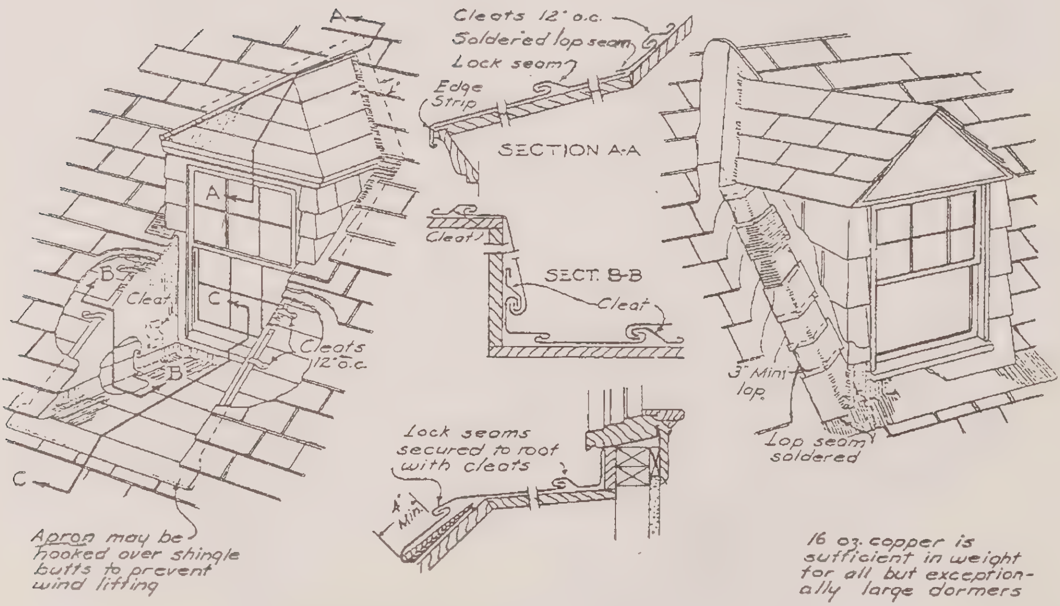
Another flashing, which is all but ignored by most writers, is a "change-in-roof-slope" flashing. *Architectural Graphic Standards* provided examples of the exposed and concealed methods of placing the flashing.



Change in Roof, Slope Flashing (Ramsey and Sleeper, p. 198)



Dormer Window Sills (Ramsey and Sleeper, p. 194)



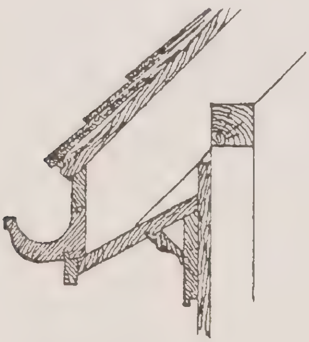
Dormer Flashing (Ramsey and Sleeper, p. 200)

9.11 SHINGLING

9.11.1 Putting on a First Course

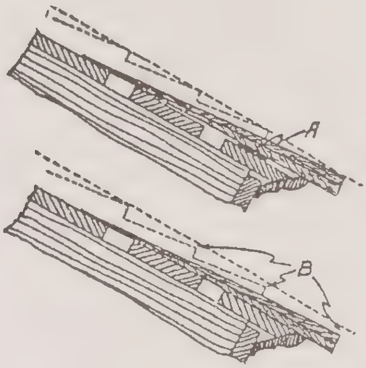
Past and modern writers on the subject of the first course of shingles or shakes are almost unanimous in asking for a doubled first course. One problem recognized at an early date was that on a three-ply roof, even with two layers of shingling at the eave, the high points of the shingle courses would not be in alignment until the starter course was further raised. The solutions proposed were varied. T.M. Clark suggested a small tilting fillet. H.H. Siegele presented two options: inserting a blocking and raising the crown moulding or doing nothing. Below is his description of the drawing:

> [Shown are] two methods of putting on the double first course of shingles. At A, upper drawing, we point out blocking that is necessary if the high points of the shingle courses are to be in alignment. This alignment is indicated by the dotted line at the top. At B, bottom drawing, the indicators point out the drop of the first three courses when the blocking is not used. The moulding shown in the upper drawing is higher than that of the bottom drawing. The upper method is technically correct, while the bottom one is more practical and more commonly used (Siegele, pp. 209-10).



Eave with Small Tilting Fillet

Two authors, Clarence A. Martin and B.L. Grondal suggested tripling the first course of shingles. Neither source referred to the problems of aligning the high points of shingles in succeeding shingle courses. Such a detail would, however, largely correct this problem.



Methods of Putting on Double First Course of Shingles.

The practice of using a lower grade shingle in double starter course situations is mentioned by other writers. A Council of Forest Industries publication recommended using a No. 2 Red Label or better shingle under a starter course of shakes (Council of Forest Industries of British Columbia, p. 2). A more common eave detail for shakes is however, a bottom course of regular No. 1 grade, 15 in. or 18 in. shakes, the former being specially manufactured for such a case (Red Cedar Shingle and Handsplit Shake Bureau, p. 3).

On the subject of how much the starter course of shingles should overhang the roof sheathing, sources generally settle on a dimension between 1 and 1½ inches.

A special nailing procedure for the starter course is described by Siegele, the only writer to do so. He suggested nailing the bottom shingle of the double course ½ in. in from the edge of the deck. In the example shown, the edge of the deck is formed by a crown moulding. The shingles are shown nailed into the upper edge of this member. The spacing of the nails would appear to be ¾ in. to 1 in. in from each edge of the shingle. Most other writers either show by illustration or imply in their text (which describes only the nailing of typical course) that the nailing of the doubled starter course is identical with that of other courses.

9.11.2 Putting on a Typical Course

Descriptions of placing a typical course of shingles cover such aspects as exposure or gauge, spacing, breaking the joints and fixing.

a. Exposure or Gauge

One of the earliest writers on the subject of shingle exposure, no less a figure than George Washington, on the subject of his leaking roof in 1783, made the observation:

> For instance, if an 18 Inch shingle shews 6 inches, two parts out of three of it is covered; so in a like manner is a 15 Inch shingle if it shews no more than 5. But I think the proportion of the hidden part should be greater – for which reason with Shingles of two feet I would shew no more than 6 inches – and with those now on the house if they are not more than 16, not more than 4 1/2, which consequently renders it more difficult for the water to penetrate... (Nelson and Dalibard, p. 39).

North American carpenters' price books from the late 18th and early 19th centuries, while short on description, were about the only published sources of the period to deal with wood shingling in any detail. The shingles and course widths priced are presumably those most commonly installed. *The Rules of Work of the Carpenters' Company of the City and County of Philadelphia*, 1786, included prices for 3-foot shingles laid in 11, 10, 9, 8 and 7 inch courses, 2-foot shingles laid in 7, 6, and 5 1/2 inch courses and 18-inch shingles laid in 4 1/2 and 4 inch courses (Peterson, pp. 5-6).

One of the earliest books to be widely distributed in North America, unlike the above-mentioned price books which were all closely held, was *The American Builder's General Price Book and Estimator,* 1833. In it were prices for 3 feet "Company's" cedar shingles at 10, 9 and 8 inch courses, and 18-inch pine shingles at 4 1/2 and 4 inch courses. The 2-foot shingle was not included (Nelson and Dalibard, p. 56).

Several mid-19th-century Canadian documents mention shingle exposure. The *Specifications for Building a Stone Blockhouse within Fort Wellington*, August 13, 1838, called for 18-inch shingles laid 4 1/2 inches to the weather (Young, p. 231). An estimate for providing *School Accommodation at Niagara*, Feb. 1851, called for 18-inch pine shingles with a similar exposure (McConnell, p. 163).

During the 19th century 16 in. shingles came to occupy a major share of the market. The trend may have arisen from the increased use made of shingle making machinery. One of the first writers to acknowledge this shift was Peter W. Plumer, 1869. Under the head "SHINGLES" he stated:

> Shingles are usually 16 inches long.... Shingles upon the roof of buildings, should never be exposed to the weather more than five inches.... (Plumer, p. 9).

One of the first writers to note a relationship between the pitch of the roof and exposure is T.M. Clark. He suggested:

> Ordinary shingles, sixteen inches long, should not show more than four-and-a-half inches to the weather, unless on very steep roofs. The thick Michigan pine shingles, eighteen and twenty inches long, can be laid with much more projection without fear of breaking or curling (T.M. Clark, p. 148).

John C. Trautwine, writing one year later, clearly prejudiced in favour of the larger shingle [27 in.] white cedar, gave an exposure for it alone:

> They...are laid in courses about 8 1/8 in. wide; so that not quite 1/3 of a shingle is exposed to the weather. They are usually laid in three thicknesses; except for an inch or two at the upper ends, where there are four (Trautwine, p. 429).

In more recent years, the calculation of exposure has been more carefully tied to the pitch of the roof. The recommendations of the Red Cedar Shingle and Handsplit Shake Bureau were representative:

> These standard exposures, which are recommended on roof pitches of five-24ths (5-in-12) and steeper, are 5 inches, 5 1/2 inches and 7 1/2 inches for 16-inch, 18-inch and 24-inch shingles, respectively. On 4-in-12 pitches these exposures should be reduced to 4 1/2 inches, 5 inches and 6 3/4 inches, respectively. On 3-in-12 pitches they should be reduced further to 3 3/4 inches, 4 1/4 inches and 5 3/4 inches, respectively, which will assure four layers of shingles throughout the roof area.
>
> While shingles last for exceeding long periods of time on steep roofs (many instances are on record where 16-inch shingles have given good service for 75 years), the exposure can not be increased beyond a point equivalent to the length of the shingle minus one inch, divided by three. In all roof construction, there should be three layers of wood at every point, to insure complete freedom from leakage in heavy wind-driven rainstorms (Grondal, p. 28).

A refinement on these sets of rules includes the grade of the shingle under consideration and modifies the exposure accordingly.

The use of shingles with a butt thickness equal to or exceeding 1 $^1/_4$ inches, today referred to as "shakes," has generated different exposure formulas. A 1945 book, *Building with Logs* recommended that 30 to 36 in. shakes, $^3/_4$ to 1 $^1/_4$ in. thick, be lapped at the sides 1 $^1/_2$ to 2 in. and overlapped at the ends 6 in. This would give an exposure of 24 in. or 30 in. Today the maximum exposure recommended for 24 in. roof shakes generally is 7 $^1/_2$ in. and 10 in. for a three ply and two ply roof respectively. For 18 in. roof shakes 5 $^1/_2$ in. and 7 $^1/_2$ in. is recommended for three ply and two ply roofs respectively (MacMillan, Bloedel, p. 3). Exposures of 10 in. and 13 in. for a 32 in. shake (now rarely, if ever produced), was recommended by the Red Cedar Shingle and Handsplit Shake Bureau in a 1969 publication (RCS & HSB, Brochure No. 17, p. 4).

Various techniques for setting out the exposure on a roof have been used. The International Library of Technology, No. 31, 1903, described one of the more common:

> The amount of exposure or gauge is measured back from the butt ends of the shingles and a mark is struck with a chalk line, to which mark the butts of the next course of shingles are laid.... (No. 31, p. 13.26).

Radford's Cyclopedia of Construction, illustrated a shingling hatched with file marks at 4$^1/_2$ and 5 in. (ordinary course dimensions). It was their contention that:

> ...in the hands of a mechanic a very good roof can be laid even without the aid of chalk lines or straight edge (Radford and Johnson, p. 227).

If the statement of H.H. Siegele is to be believed, the earlier methods were in fact dropped in favour of the specially adapted shingling hatchet:

> Wood shingles, in these days, are almost exclusively spaced by means of a shingling gauge fastened to the hatchet (Siegele, p. 208).

b. Spacing

It is uncertain when the benefits of properly spaced shingles were first recognized. The earliest reference to the subject was found in a 1903 publication:

> In laying shingles on a roof, the best results are obtained, and their endurance, which is the chief point, is vastly increased by setting the shingles from $^3/_{16}$ to $^1/_2$ apart. This allows the water to drain off rapidly, dries the roof quickly, and also allows for expansion and prevents buckling. Where narrow shingles are used, the joints should not be less than $^1/_8$; while for shingles over 5 in. in width, from $^1/_4$ to $^1/_2$ joints should be allowed (International Library of Technology, No. 31, p. 13-33).

The minimum $^1/_8$ in. spacing rule suggested by the International Library of Technology text for narrow shingles is extended to cover all shingles in *Light Frame House Construction*, a 1931 publication (U.S. Office of Education, p. 143).

A procedure for achieving a proper spacing which requires pre-wetting of the shingles is suggested by the Shingle Manufacturers Association of B.C. writing in *Specification Data*:

> If shingles are not to be stained, thoroughly wet them before laying; if to be stained, lay dry, but not closer than $^3/_8$ in. (*Specification Data*, p. 53).

Grondal, writing in 1964 for the Red Cedar Shingle and Handsplit Shake Bureau, was quite specific in recommending against this very procedure:

> Shingles should be not wetted before they are laid on a roof, but should be at the average moisture content that the bundles will reach while in ordinary storage in the retail lumberman's yard. Proper attention should, of course, be paid to spacing, so that there will be sufficient room for expansion during rainy weather. A space of $^1/_4$ to $^3/_8$ inch between the edges of adjacent shingles will allow for this expansion. The best possible moisture content for the shingles at the time of application, based upon an extended series of measurements of shrinkage and expansion stresses between the nails during the course of an investigation in the laboratories of the College of Forestry of the University of Washington, was found to be 15 percent, so that a range of moisture content between 10 percent and 18 percent, the average moisture content that shingles reach in storage, will give the best results. When thoroughly wet or green shingles are nailed on a roof, splits and checks may occur, due to the shrinkage stresses which develop between the nails (Grondal, p. 49).

Modern writers on the subject of spacing are now in general agreement that shingles be spaced 1/4 in. and shakes 1/4 – 3/8 in.

c. Breaking Joints

As in the case of "spacing", it is uncertain when the importance of breaking the joints in succeeding course of shingles was first recognized.

Radford's Cyclopedia of Construction included the following comments on the joints of a section of wood shingled roof:

> Three courses of shingles are laid on the roof to three chalk lines. Not a single joint comes over another, not even from the first to the fourth courses, so if one should split right at another joint it only makes a crack less than two-thirds the length of a shingle (Radford and Johnson, p. 225).

The earliest reference which gave a recommended offset dimension is *Specification Data:*

> Break all joints at least 1 1/4 in. sidelap and provide for no break coming directly over another on any three consecutive courses (*Specification Data,* p. 53).

H.H. Siegele recommended a minimum overlap of 1 inch.

In *Architectural Specifications* and in later handbooks, the usual sidelap is given as 1 1/2 inch (Sleeper, p. 393).

d. Fixing

No detailed descriptions of fixing shingles to roof sheathing or framing members, written in the early 19th century or before, have been discovered. Edwin C. Guillet, in his book *Pioneer Arts and Crafts,* suggested that the earliest type of handsplit shingles, about 3 feet in length, were fastened to the pole rafters (split cedar, 4 in. wide) by wooden pins (Guillet, p. 6).

A tradition of nail attachment is more common and better documented. John Stevens, in his article "Shingles", stated:

> Shingling on laths usually involved an exposure of from 10" to 15", and as a result the shingles had to be butt-nailed. Many examples of this practice survive on walls, but naturally few roofs have remained to confirm such usage. A drawback of this practice was the possibility of leakage around the exposed nails. The best extant examples known to the writer date from as late as c. 1750, and have clipped corners....
>
> Apparently after the above date and through a transition period of unknown duration...roof shingles became shorter and had less exposure which thereby eliminated the need for butt-nailing....
>
> From the third quarter of the 18th century.... Butt-nailing, which previously had been done by eye, became controlled by lines that were scribed, as with the point of a nail or other pointed instrument, along a straight edge. A chalk line might have been snapped along the shingle row first. Some examples have double lines for staggered nailing (Stevens, pp. 75-76).

Not all early shingles were 3 feet long and butt nailed, however. A section of roof, pre-1780 from the Louisbourg townsite, was found by archaeologists with most of its wood shingle finish intact. The 1.40 ft. (17 in.) long shingles, with .40' (4 3/4 in.) weather were attached to the horizontal board sheathing with .10 ft. (1 1/4 in.) long (broad, faceted head, four sided tapering shank) wrought nails. The nailing was concealed (Cox, p. 68).

Descriptions of concealed nailing by 19th-century writers are generally vague on the placing of the nails; i.e. "two nails are used to each shingle, near its upper end" (Trautwine, p. 429).

Not all mechanics were in agreement on nail placing, however. *Radford's Cyclopedia of Construction*, 1909 made the observation:

> Long old mechanics that have had twice as much experience in house building say nail as high as possible. They say the higher in the shingle you nail, the more air will get to all parts of the shingle and it will last longer, which is undoubtedly true. Another with possibly even more experience will say nail just as low as possible and have the nail covered with the next course, and gives for his reason that higher winds and heavy rain and snow storms will not drive in (Radford and Johnson, p. 224).

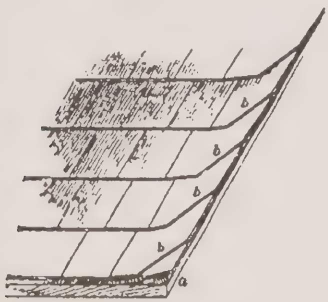
The tendency among modern writers seems to be towards keeping the nails relatively close to the butt line of the following course. In the case of shingles, a dimension (above the butt line

of the course to follow) between $1^1/_2$ in. and 2 in. is most often requested. In the case of shakes, a dimension between 1 in. and 2 in. is usually asked for. A distance in from each edge of $^3/_4$ in. is suggested for both shingles and shakes.

9.11.3 Finishing a Gable Rake

A special problem of drip over the gables of a shingled roof has long been recognized by mechanics working in the field. The solution suggested by the International Library of Technology, consisted in:

> ...putting a tilting fillet up the rake, running the shingles up on it as at *a* and cutting the ends of the shingles at an angle of 45° to the side joint, as shown at *b* (No. 31, p. 13.31).



Preventing Drip from the Gables of a Shingled Roof

Grondal substituted a standard profile strip of siding for the fillet and reduced the angle of the cut shingle ends but otherwise advocated a similar procedure.

Split-shake roofs, according to Donald H. Clark, are "less prone to drip rainfall or snow-melt from the gables than are roofs of smoother materials" (p. 28). This may explain his calling for a cedar level siding for use as a tilting fillet and his neglect in mentioning any special cutting in the edge shakes themselves.

9.11.4 Finishing a Valley

Generally two methods of finishing a valley on a shingle roof have been and continue to be used by mechanics. The first consists of laying a long strip of metal flashing the length of the valley, fixing it to the roof at the edges and laying the shingles to lap over it on each side, leaving a space in the centre of the valley. The finished valley is referred to as an "open valley." The second method consists of "shingling in" flashings in each course of shingles over the length of the valley and running the shingles of each roof plane to within a short distance of each other. The finished valley is referred to as a "closed valley." Historical descriptions of both methods are discussed in the sections on flashing.

a. Open Valley

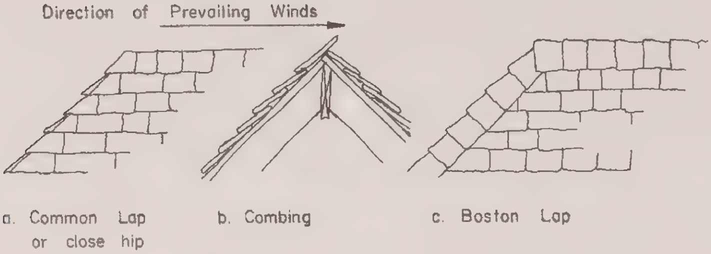
When installing an open valley, the shingler could use a chalk line or a straight edge to maintain an even line when cutting the shingles. It was important not to nail towards the centre of the valley flashing and not to introduce broken joints into the valleys (Hicks, 1894; International Library of Technology, No. 31, 1903; Grondal, 1964).

b. Closed Valley

From a very early date, it appears mechanics were aware of the limitations of the closed valley. Continual references are found on employing the detail only on roofs of steeper pitch or in areas of the country with a dryer climate. This caution is quite evident in the description of a "close valley" offered by the International Library of Technology:

> In constructing *close* valleys, the shingles are interwoven with metal sheets... and are mitered in the angle....
>
> The general manner of constructing this valley is as follows: A row of shingles should be laid each side of the valley, a clear space of $^1/_2$ inch being kept between the miter edges... to allow for expansion. The gauge should then be measured, and the flashing set ... to the line so obtained; the next course of shingles... covers the metal entirely, and each ascending flashing will be covered in like manner. This gives a tight valley and is used more on account of appearance than durability; for the snow and rain keep the shingles damp, consequently causing them to rot before the rest of the roof (No. 31, pp. 13.2-29).

One of the few innovations which have been made in closed valley installations in recent years is the partial filling of the valley or saddle with a wood strip (D.H. Smith, p. 23). The benefit derived from using this strip is not explained.



Shingling Ridges and Hips (Parker, Gay and MacGuire, p. 199)

9.11.5 Finishing a Hip or Ridge

Generally three techniques of finishing hips and ridges have been used by mechanics: using only shingles or shakes, using ridge boards and using a stock ridge roll. Historical descriptions of each technique are collected under the appropriate heading.

a. Shingle/Shake

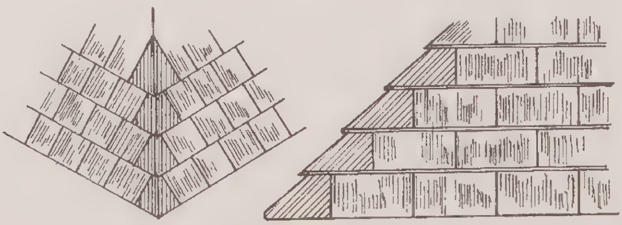
A very simple method of finishing a ridge consists of "cutting the shingles on the leeward side flush with the top of the ridge and running them on the windward side an inch or two over and past the ends of the cut-off shingles" (Parker, Gay and MacGuire, p. 198). This technique of having the "combing" project away from the direction of prevailing winds, while badly documented in printed sources, was undoubtedly a very early solution to finishing a ridge.

Another technique, generally ignored by writers, is what Parker, Gay and MacGuire referred to as a "common lap" or "close hip:"

> In a close hip the shingles of the regular courses are cut off flush with the line of the hip, a shingle on each side alternately lying over a shingle on the other side (Parker, Gay and MacGuire, p. 199).

The technique is shown as applied to both hip and ridge situations. *Radford's Cyclopedia of Construction*, 1909, provided a detailed description of the same method applied to hip-ridges [hips]:

> ...two or three courses should be left off at the ridge [hip] until the two sides are brought up; then the courses left off should be laid on together, and in such a manner as to have them lap over each other alternately....
>
> There are several methods of shingling over a hip-ridge; one is the old and well-tried method of shingling with the edges of the shingles so cut that the grain of the wood runs parallel with the line of the hip ....
>
> The proper way to put in these shingles is to let the ends run over alternately and then dress them to the bevel of the opposite side of the roof.... (Radford and Johnson, pp. 222-23).



Shingling over a Hip-ridge; shingling with the edges of the shingles cut so the grain of the wood runs parallel with the line of the hip...

Undoubtedly the most popular method of finishing a hip was the so called "Boston Hip." One of the few sources to attempt an adequate description of the method was the International Library of Technology:

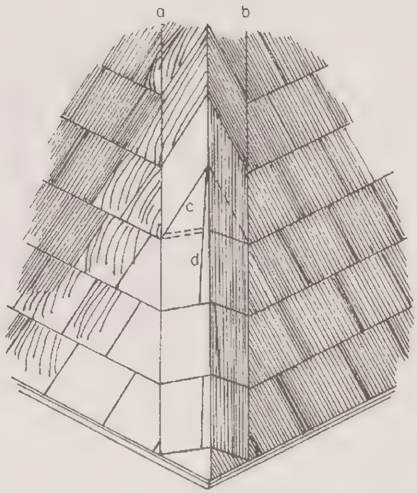
> Shingles of a uniform width of, say, 5 inches, should be selected. A chalk line is snapped on either side of the hip, about 4 1/2 inches from its center and parallel to it.... The slope shingles [on the main roof] should be carried up to this line, stepping back to allow the hips to be laid last. Lay a shingle on the roof with its edge at, and parallel to, the hip line, and the lower corner of its butt just touching the butt of the shingle below it, as shown at *b*. Across it, and at right angles to the eaves, draw a line for the vertical side cut, as at *c*. Slightly taper the side *d*. to heighten the effect of a hip roll, and to allow the next hip shingle above to slightly project over and cover the end of the vertical side cut. Fit the hip shingle to the side of the slope shingle, and nail in place. On the other side, lay the edge of the shingle flush with the upper and outside edge of the first shingle, obtaining the side and butt cuts in the same manner as before; the third shingle is laid on the same side as the second; the fourth shingle is laid on the same side as the first, with the hip edge flush with the outside edge of the third, and the fifth on the same side as the fourth; continue thus, laying two alternately, until the hip is completed.
>
> One of the chief advantages of this method is, that the grain of the wood runs with the hip, and the tendency to curl is taken away from the line of the hip to the side of the shingle (No. 31, pp. 13.30-31).

Possibly because of the degree of cutting and fitting required with the "Boston" hip method, a simpler version was devised. Called the modified "Boston hip" in the *Certigrade Handbook*, it does away with the vertical side cut and the step of fitting against the main roof shingles.

Today, pre-cut hip and ridge units are sold which in appearance match exactly the modified "Boston" hip.

b. Ridge Boards

Three methods of finishing the ridge of a roof were discussed in the International Library of Technology. All are variations on the ridge board idea. The first consisted of:



Boston Hip

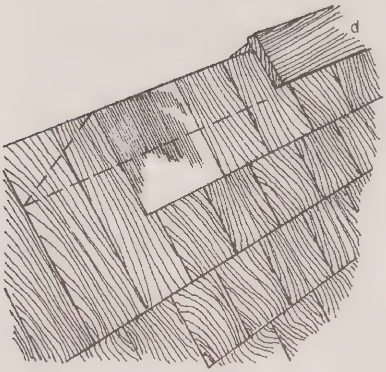
> ...laying over the last row of shingles but one, a metal flashing ...which extends on each side of the ridge to the depth of the last row, after which the last row of shingles may be laid and the ridge capped with a ridge saddle of white pine... 1/4 inches thick. The first side... is put on flush with the ridge and opposite side of the roof, and the finished piece is put on with a lap of about 1/2 or 3/4 inch (No. 31, pp. 13.31).

The second method consisted of:

> ...two ridge pieces... one being the thickness of the board wider than the other, laid over two pieces just the thickness of the shingles, which are first nailed to the roof-boards, and against which the shingles abut. The top of the ridge piece is capped with a wooden roll.... No metal flashing is required, as the roll effectually covers the joint (No. 31, pp. 13.31-32).

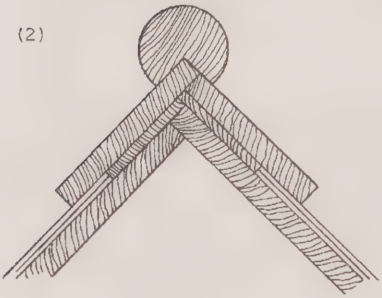
The third method described is similar to the second in all respects except:

> ...the wood roll is covered with a galvanized-iron or copper roll and wings pushed over it (No. 31, pp. 13-32).

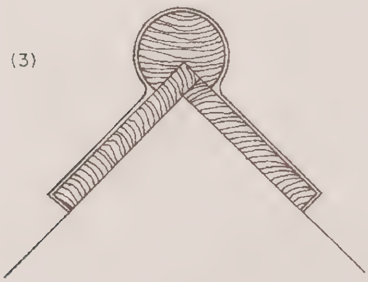


Finishing Ridge of Roof

(2)



(3)



Finishing Ridge of Roof

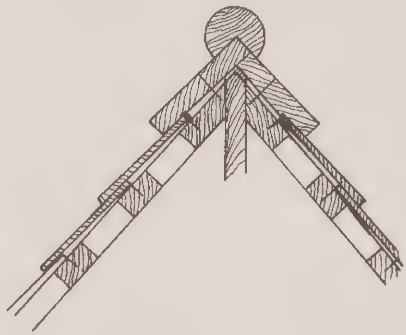
c. Stock Ridge Roll

By the turn of the century, stock ridge rolls, formed usually in galvanized iron or steel, were available to roofers for use on either hips or ridges. While admitting that they made a weatherproof hip, the International Library of Technology also states:

> The roll, however, never looks well, and on that account should be avoided (No. 31, p. 13.30).

Siegele, writing in 1942, had no such hesitancy in recommending the stock ridge roll:

> …a metal ridgeroll... is commonly used in these days because it is inexpensive and makes a waterproof job (Siegele, p. 209).



Detailed Drawing for a Stock Roll
(Ramsey and Sleeper)

9.11.6 Staining and Painting

A description of the various methods of painting a shingle roof were supplied by T.M. Clark:

> The painting of a shingle roof is important. Many architects specify that each shingle shall be dipped in paint, some even requiring the paint to be hot; but this is tedious and expensive. A simpler and very good way is to paint each course as it is laid; and the cheapest is to do it all at once after the roofers are out of the way. The last process rather hastens the decay

> of the shingles, by forming little dams of paint which hold back the rain-water against the unprotected portions, but is usually adopted (T.M. Clark, p. 149).

Techniques for staining shingles, well established by the turn of the century, differ only slightly.

An alternative to site dipping of the shingles was to buy a factory stained shingle. The Creo-Dept. Company, Inc. of North Tanawanda, NewYork, listed in *The American Architect Specification Manual*, 1921, was a supplier of thatched "Creo-Dept." stained shingles in Thatch A, Band C shades.

10.0 BIBLIOGRAPHY

American Architect, The. 1921. *The American Architect Specification Manual*. 3rd edition. The Architectural and Building Press, New York.

Andrews, Ralph W. 1957. *This Was Sawmilling*. Bonanza Books, New York.

Bixby, M.G. and Co. 1886. *Industries of Canada, Historical and Commercial Sketches of Toronto and Environs, Its Prominent Places and People, Representative Merchants and Manufacturers, Its Improvements, Progress and Enterprises*. M.G. Bixby and Co., Toronto.

Brees, S.C. 1853. *The Illustrated Glossary of Practical Architecture and Civil Engineering: Comprising the Theory and Modern Practice, with the Subjects of Office and Field Work*. L. A. Lewis, London.

Canada. Department of Resources and Development. 1951. *Canadian Woods, Their Properties and Uses*. 2nd edition. Forestry Branch. King's Printer, Ottawa.

Canada. National Archives. n.d. *Tom Douglas Lane Papers, II – Business Documents (1835-1875)*. M.G. A40. Ottawa.

Cedar Shake and Shingle Bureau. 1989. *Design and Application Manual for New Roof Construction*. Bellevue, WA.

Clark, Donald H. 1971. *Certi-Split Manual of Handsplit Red Cedar Shakes*. Red Cedar Shingle and Handsplit Shake Bureau, Seattle, WA. Quoted material reprinted by permission: Cedar Shake & Shingle Bureau, Bellevue, WA.

Clark, T.M. 1886. *Building Superintendence: A Manual for Young Architects, Students, and Others Interested in Building Operations as Carried on at the Present Day*. Ticknor and Co., Boston.

Clifton-Taylor, Alec. 1977. *The Pattern of English Building*. Reprint of 1972 edition. Faber and Faber, London.

Cox, Richard E. 1970. "Wooden Shingles from the Fortress of Louisbourg," *Bulletin of the Association for Preservation Technology*, Vol. 2, Nos. 1-2, pp. 65-69. Quoted material reprinted by permission: ©1970, APT.

Dilworth, J.R. 1977. *Log Scaling and Timber Cruising*. Revised edition. OSU Cooperative Association, Corvallis, OR.

Edlin, H.I. 1973. *Woodland Crafts in Britain*. 2nd edition. David and Charles, Newton Abbot, Devon, UK.

Fickes, Clyde P., and W. Ellis Groben. 1974. *Building With Logs*. Reprint of 1945 edition. Shorey Book Store, Seattle, WA.

Finch and Apgar. 1881. *Handbook of Useful Tables for the Lumberman, Farmer, and Mechanic*. Finch and Apgar, Ithaca, NY.

Follansbee Steel Corp. 1976. *T.C.S Terne-Coated Stainless Steel Specifications and Data Manual*. Form No. 30.5 MA976. Follansbee Steel Corp, Follansbee, WV.

Forest Industries of British Columbia, Council of. 1972. *Specification Guide for Western Red Cedar Shingles and Shakes*. 72-194. Revised, 1975. Vancouver.

Gardner, E.C. 1874. *Homes, and How to Make Them*. James F. Osgood and Co., Boston.

Grondal, Bror L. 1964. *Certigrade Handbook of Red Cedar Shingles*. 13th edition revised. Red Cedar Shingle and Handsplit Shake Bureau, Seattle, WA. Quoted material reprinted by permission: Cedar Shake & Shingle Bureau, Bellevue, WA.

Guillet, Edwin C. 1968. *Pioneer Arts and Crafts*. Revised edition. University of Toronto Press Inc., Toronto. Quoted material reprinted by permission: University of Toronto Press, Inc.

Hammond, James J., et al. 1961. *Woodworking Technology*. McKnight and McKnight, Bloomington, IL.

Hicks, I.P. 1894. *Hicks' Builders' Guide, Comprising an Easy, Practical System of Estimating Material and Labour for Carpenters, Contractors and Builders*. David Williams, New York.

Hildebrandt, Walter. 1978. *Fort Battleford: A Structural History, Volume I: Building Reports*. Manuscript Report Series, No. 252. National Historic Parks and Sites Branch, Parks Canada, Ottawa.

Holland, Leicester B., and Harry Parker. 1926. *Ready Written Specifications, A Compendium of Clauses, for Direct Use in Architectural Specifications.* John Wiley & Sons, New York.

ICS Reference Library. 1904. *Carpentry Joinery, Stair Building, Geometrical Drawing, Architectural Drawing, Estimating and Calculating Quantities, Specifications.* No. 14, International Textbook Co., Scranton, PA.

Insall, Donald W. 1972. *The Care of Old Buildings Today: A Practical Guide.* The Architectural Press, London.

International Library of Technology. 1901. *A Textbook on Sheet-Metal Pattern Drafting.* No. A-2: *Practical Projection, Development of Surfaces, Practical Pattern Problems, Architectural Proportion, Development of Moldings, Skylights.* International Textbook Co., Scranton, PA.

__________. 1903. No. 30: *Masonry, Carpentry, Joinery…*

__________. 1903. No. 31: *Roofing, Sheet Metal Work, Building Superintendence, Contracts and Permits.*

__________. 1909. No. 33B: *Fireproofing of Buildings, Stair Building, Ornamental Metal Work, Builders' Hardware, Roofing, Sheet-Metal Work, Mill Design.*

Kidder, Frank Eugene. 1915. *The Architects' and Builders' Pocket-Book.* 16th edition rev. John Wiley and Sons, New York.

Macey, Frank W. 1922. *Specifications in Detail.* 3rd edition revised. Crosby Lockwood and Son, London.

Mackie, B. Allen. 1972. *Building with Logs.* 2nd edition. B. Allen Mackie and Ida Mary Mackie, Prince George, BC.

Mackie, Mary., ed. 1975. "Splitting Cedar Shakes," *The Canadian Log House,* No. 2 (Spring), pp. 23-27. Quoted material reprinted by permission.

MacMillan Bloedel Ltd. 1969. *Western Red Cedar Shingles and Shakes* MB425. Vancouver.

Martin, Clarence A. 1908. *Details of Building Construction.* Bates and Guild Co., Boston.

McConnell, David. 1977. *A Study of the British Military Buildings at Niagara-on-the-Lake, 1814-37.* Manuscript Report Series, No. 191. National Historic Parks and Sites Branch, Parks Canada. Ottawa.

Mercer, Henry C. 1951. *Ancient Carpenters' Tools, Together with Lumberman's, Joiner's and Cabinet Maker's Tools in Use in the Eighteenth Century.* 2nd edition. Bucks Country Historical Society, Doylestown, PA.

Metallic Roofing Co. of Canada, The. 1904. *Catalogue "A."* Toronto.

Mortimer, C.H., Publishing Co., The. 1901. *Canadian Contractors' Hand-Book and Estimator.* 3rd edition. Toronto.

National Research Council of Canada. 1977. *National Building Code of Canada.* 7th edition. Ottawa.

Nelson, Lee H., and Jacques Dalibard., eds. 1970. "Early Roofing Materials," *Bulletin of the Association for Preservation Technology,* Vol. 2, Nos. 1-2, pp.18-88. Quoted material reprinted by permission: ©1970, APT.

Pacific Coast Lumber Manufacturers' Association. 1908. *Standard Classification, Grading and Dressing Rules for Douglas Fir, Spruce, Cedar and Hemlock Lumber and Red Cedar Shingles.* Revised edition. Seattle, WA.

Painters Magazine, The. 1909. *One Thousand More Paint Questions Answered.* New York.

Parker, Harry, Charles Merrick Gay and John W. MacGuire. 1958. *Materials and Methods of Architectural Construction.* 3rd edition rev. John Wiley and Sons, New York.

Peterson, Charles E., ed. 1971. *The Rules of Work of the Carpenters' Company of the City and County of Philadelphia 1786.* 1st facsimile edition. Pyne Press, Princeton, NJ.

Plumer, Peter W. 1869. *The Carpenters' and Builders' Guide, Being a Hand-Book for Workmen, also a Manual of Reference for Contractors, Builders, etc.* Hoyt, Fogg & Bree, Portland, OR.

Radford, William A., and Alfred Sidney Johnson, eds. 1909. *Radford's Cyclopedia of Construction, Carpentry, Building and Architecture.* 12 vols. Vol. 2: *The Practical Carpenter, Elements of House Framing, Foundations, Walls, Windows, Joints, Girders, etc., covering of Roofs; Mouldings, Special Joints and other Fastenings; Stair Building, Architectural and Miscellaneous Framing.* Vol. 12: *Construction Contracts, Specifications, Estimating, Builders' Hardware, General Index.* Radford Architectural Co., Chicago.

Ramsey, Charles George and Harold Reeve Sleeper. 1941. *Architectural Graphic Standards.* 3rd edition. 5th edition 1956. John Wiley & Sons, New York. Quoted material and illustrations reprinted with permission. © John Wiley & Sons, Inc.

Red Cedar Shingle and Handsplit Shake Bureau. n.d. *Red Cedar Shingles, Handsplit Shakes and Grooved Sidewall Shakes.* Brochure No. 17. Vancouver.

Rempel, John I. 1976. *Building with Wood and Other Aspects of Nineteenth-Century Building in Ontario.* Reprint of 1967 edition. University of Toronto Press, Toronto. Quoted material reprinted by permission: University of Toronto Press, Inc.

Ritchie, Thomas. 1967. *Canada Builds 1867-1967.* University of Toronto Press, Toronto.

Shannon, J.B. 1873. *Illustrated Catalogue and Price List of Carpenters' Tools.* Catalogue No. 7. Philadelphia, PA.

Siegele, H.H. 1942. *Carpentry Craft Problems, A Complete Practical Book of Instruction.* Frederick J. Drake, Chicago.

Sleeper, Harold Reeve. 1940. *Architectural Specifications.* John Wiley and Sons, New York. Quoted material reprinted by permission.

Sloane, Eric. 1973. *A Museum of Early American Tools.* Ballantine Books, New York. Quoted material reprinted by permission: Estate of Eric Sloane.

Specification Data. 1921. Toronto.

Stevens, John. 1970. "Shingles," *Bulletin of the Association for Preservation Technology,* Vol. 2, Nos. 1-2, pp. 74-76.

Trautwine, John C. 1887. *The Civil Engineer's Pocket-Book, of Mensuration, Trigonometry, Surveying, Hydraulics, Hydrostatics, etc.* 12th edition rev. John Wiley and Sons, New York.

Trow, Harris C., ed. 1911. *Cyclopedia of Drawing.* 4 vols. American School of Correspondence, Chicago.

U.S. Department of Commerce. 1940. *Light Frame House Construction.* Reprint. Vocational Division, Bulletin No. 145, Trade and Industrial Series No. 41. U.S. Government Printing Office, Washington, DC.

Viires, A. translator. 1969. *Woodworking in Estonia.* Program for Scientific Translations, Jerusalem.

Waite, Diana S. 1971. *Nineteenth Century Tin Roofing and its Use at Hyde Hall.* New York State Historic Trust, Albany.

Walker, Frank R. 1927. *The Building Estimator's Reference Book.* 6th edition. Frank R. Walker Co., Chicago.

Welsh, Peter C. 1966. *Woodworking Tools 1600-1900.* Contributions from the Museum of History and Technology, Paper 51, pp. 178-228.

Wigginton, B. Eliot., ed. 1972. *The Foxfire Book.* Doubleday & Co., Garden City, NJ. Quoted material and illustrations reprinted by permission: *The Foxfire Book.* Copyright 1968, 1969, 1970, 1971, 1972 by the Foxfire Fund, Inc., Doubleday, a division of Bantam Doubleday Dell Publications Group, Inc.

Young, Richard J. 1973. *A Comparative Report and Catalogue of Blockhouses in Canada.* Manuscript Report Series, No. 155. National Historic Parks Branch, Parks Canada. Ottawa.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

9.2

PERIOD ROOFING

SLATE ROOFING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: G. SIMISON

CONTENTS

1.0 INTRODUCTION

Slate roofing is an early roofing method still in use today. Because of the nature of the material, the methods of production and application have changed little over the years.

Slate has many practical and attractive characteristics: resistance to the action of the elements (slate roofs can be effective for well over one hundred years); fireproofing qualities; low maintenance requirements; variety in colour, texture and thickness and high salvage value.

Slate stone is a metamorphic rock quarried in slabs that can be split into thin layers. Although brittle, slate is often extremely hard and close in texture, capable of indefinitely withstanding the most smoke-laden atmospheres.

Production and promotion of slate has continued to our day and is available in Canada, the United States and Europe. Slate companies today are still referring to information and details published in 1926 by the National Slate Association:

> This book is reproduced as a service to the slate industry and its customers.
>
> We acknowledge with deep gratitude the work done by the National Slate Association resulting in this publication in 1926. In the interest of preserving this work we have refrained from any editorial revisions.
>
> There has been little change over the years as far as methods of quarrying, fabrication and installation. We urge you to check the availability and suitability of slates currently being quarried (Doney Slate Co., p. 1).

Slate is suitable for either sloping or flat roofs. It has also been used as a wall covering in the past and present.

This article deals with period methods of quarrying, extracting, shaping and laying slate roofs. The links between these methods and contemporary methods will be noted whenever possible.

Today, slate companies in Vermont and Virginia are producing roofing slate to meet North American demand. However, it seems that a major part of slate production is focused on flooring and wall panels to be applied to the exterior of modern buildings.

2.0 MATERIAL

2.1 QUARRYING

Slate is quarried by different methods, depending upon the structure and bedding of the rock.

Sometimes the deposits are in nearly vertical beds, but curve back and forth at steep angles or the bedding dips at a 15° to 60° angle.

The vertical beds permit a small surface opening which can be worked to great depth and operated for many years without the expense of removing the overburden. Where the beds are at an angle, it is necessary to "strip" or remove large quantities of waste rock or earth.

Penrhyn Quarry, Wales, 1890
(Lindsay)

Hand drills, machine drills and blasting are used to some extent, depending upon the location of the bed. Some quarries use channeling machines, run by steam or compressed air, which give a smooth surface and provide a means of obtaining regular rectangular blocks.

After the block is cut by the channeling machine, it is necessary to separate it from the floor. Where there are no seams, horizontal drill holes are projected at the floor of the trench parallel to the slate cleavage. Black blasting powder exploded in small charges then marks a fracture, separating the mass from the floor. These large masses are subdivided into slabs by splitting along the cleavage plane. These can then be hoisted to the surface by derricks or more commonly by cableways.

From the cableways the blocks are placed on cars at the landing and drawn to a mill or shanty. At the largest and most up-to-date quarries, gasoline engines draw the cars directly into the mill. Here the slabs are lifted by electric travelling cranes and placed on saw tables where they are cut and later "sculped" into conveniently sized slabs for the slate splitter.

The slate splitter, using a flexible chisel and wooden mallet, splits the slab first in the centre and continues to subdivide it in the centre until it is split to the required thickness. The final pieces are then trimmed to commercial size, either on a foot treadle machine or by a mechanical trimmer. They are then hauled to the storage yards and set on edge, each pile made up of slates of the same size. Slates are sometimes punched with nail holes before piling, at other times just before shipment and sometimes on the job (Ritchie, p. 194).

In the old quarry fields everything was done by hand, with some larger blocks moved by one-horse dumpcart. Nail holes were drilled manually by holding a slate up and striking it with a hammer. Blasting was done by black powder, splitting and cutting by hand and the waste was wheeled out on a wheelbarrow (*Grandfather's Book of Country Things*. Needham and Mussey, p. 52).

Penrhyn Quarry, Wales, Showing Quarrymen using Pneumatic Drills (Lindsay)

Slate Blocks Being Lifted by Hand-worked Pulleys
Votty and Bowydd Quarry, Wales (Lindsay)

A Slate Dressing Mill with a Line of Saw Tables
Llechwedd Quarry, Wales (Lindsay)

Slate Dressing: The Beginning of Sculping (Eckel)

Slate Slitter, Ceudwll Llechwedd Slate Caverns, (open to tourists), Wales (K. Elder)

Dinorwic Quarrymen's Train, The Amalthea, *ca. 1900*
(Lindsay)

Port Dinorwic – Steamer in Dry Dock
(Lindsay)

Thomas Ritchie mentioned in his book *Canada Builds* that except for mechanization in lifting and moving the heavy loads of slate, the basic methods of extracting and splitting of slate have not changed. In Canada, by the turn of the century, there were quarries in Ontario (Madoc) and in Hants and Halifax counties in Nova Scotia. As well as those in Quebec, quarries also flourished in Nova Scotia and New Brunswick in the Bay of Fundy. There were none on the prairies, but in British Columbia two were operated at Glenogle and at the head of Jervis Inlet. With the exception of those in Quebec, Canadian quarries were small, producing just enough slate for local use. In Newfoundland, however, Welsh quarrymen turned large slate deposits into a thriving export business until the turn of the century, when other cheaper roofing materials were developed. (Ritchie, pp. 194-95).

2.2 CHARACTERISTICS

2.2.1 General Qualities

Slate quarried for roofing stock is of dense, sound rock that is exceedingly durable. It becomes harder and tougher upon exposure than when first quarried:

> A good slate should be both hard and tough. If the slate is too soft, however, the nail-holes will become enlarged and the slate will become loose. If it is too brittle the slate will fly to pieces in the process of squaring and holing and will be easily broken on the roof. "A good slate should give out a sharp metallic ring when struck with the knuckles; should not splinter under the slater's axe; should be easily HOLED without danger of fracture, and should not be tender or friable at the edges." The surface when freshly split should have a bright metallic luster and be free from all loose flakes or dull surfaces. Very few of the Vermont slates, however, have the metallic luster or ribbons. Most slates contain ribbons or seams which traverse the slate in approximately parallel directions. Slates containing soft ribbons are inferior and should not be used in good work (Kidder, p. 1496).

Around the turn of the century criteria were established for the quality of slate according to its various characteristics such as colour, texture, weight, thickness, size and resistance to the elements.

2.2.2 Colour

Colour is determined by chemical and mineral composition. Since these factors differ in various localities, it is possible to obtain a variety of colours. The colour of the slate does not indicate its quality. Slate changes colour upon exposure to weather. The extent of this colour change varies with different slate beds. These characteristics should be taken into consideration when colour is an essential element of roofing, especially in repairs where it should match the remaining original parts.

According to the U.S. National Slate Association (1926), basic colours of slate in North America are: black, blue black, grey, blue grey, purple, mottled purple and green, green and red. The colouring minerals are chlorite in the greens, hematite in the purples and hematite and iron oxide in the red.

Slate often contains veins or ribbons of a different colour. While these do not impair the strength of the slate, they are objectionable in appearance.

2.2.3 Texture

Many slates split to a smooth surface, while others are somewhat rough and uneven. This creates a wide range of surface effects for the finished roof.

2.2.4 Weight

The weight of slate varies according to its size, colour and quarry. A square of slate (amount that covers 100 square feet of roof) with a commercial standard thickness of $^3/_{16}$ in. and standard 3 in. lap weighs 650-750 pounds. A dead load of eight pounds per square foot includes slate, felt and nails.

2.2.5 Thickness

The *Architects and Builders Pocket Book* stated:

> ...Slates vary in thickness from $^1/_8$ to $^3/_8$ in.; $^3/_{16}$ in. is the usual thickness of ordinary sizes. ...It is of utmost importance for architects to specify the thickness of slates, either fully $^3/_{16}$ in. thick, or fully $^1/_4$ in. thick, to secure a strong and durable roof (Kidder, p. 1497).

Common thicknesses of slate have not changed over the last one hundred years. The Vermont Structural Slate Company, Inc., Fair Haven, VT, is at present advertising a slate thickness range of 1 in., $^3/_4$ in., $^1/_2$ in., $^3/_8$ in., $^1/_4$ in. and $^3/_{16}$ in., considering their standard thickness to be $^3/_{16}$ in.-$^1/_4$ in.

2.2.6 Size

The sizes of slates range from 6 by 6 in. to at least 24 by 14 in. According to Kidder, in 1915 the most popular sizes were from 8 x 16 to 10 x 20, with 9 x 18 the most common.

The Buckingham Virginia Slate Corporation advertised in 1967 sizes ranging from 10 x 6 to 26 x 14, while the Vermont Structural Slate Company advertises available lengths of 12 in., 14 in., 16 in., 18 in., 20 in., 22 in. and 24 in.

Smaller slates are sometimes used at the crest of the roof and larger at the bottom (eaves) which reduces the weight towards the crest or ridge and gives a more pleasing appearance.

2.2.7 Resistance to Elements

Slate is fireproof, waterproof, practically non-absorptive and resistant to weather. It is of high salvage value and requires no other materials to preserve it.

2.2.8 Grading of Slates

According to estimators' handbooks from the turn of the century, the quality of slate was established according to grading criteria:

> Slates are classed according to their straightness, smoothness of surface, fair even thickness, presence or absence of discolouration, etc. They are generally divided into first and second qualities and in some cases a medium quality is quoted. Slates of first quality are thinner and lighter than those of inferior quality (Hodgson, p. 148).

The following is a sample description of the grades for slate:

> **Grading of Slates**. The Monson, Me., slates and Brownville, Me., slates are graded as follows: No. 1. Every sheet to be full $^3/_{16}$ in. thick, both sides smooth and all corners full and square. No pieces to be winding or warped.
>
> No. 2. Thickness may vary from $^1/_8$ to $^1/_4$ in., all corners square, one side generally smooth, one side generally rough, no badly warped slates.
>
> The Bangor, Pa., slates are graded: No. 1 Clear. A pure slate without any faults or blemishes.
>
> No. 1 Ribbon. As well made as No. 1 Clear, except that it contains one or more RIBBONS (a black band or streak across the slate), which, however, are high enough on the slate to be covered when laid, thus presenting a No. 1 roof.
>
> No. 2 Ribbon. This contains several RIBBONS, some of which cannot be covered when laid.
>
> No. 2 Clear. A slate without RIBBONS, made from rough beds.
>
> Hard Beds. A clear Bangor slate, not quite as smooth as No. 1 Clear, but much better than No. 2 Clear. Ordinary Bent Slate. A smooth slate similar to No. 1 Clear, but bent at a radius of about 12 ft. (Kidder, p. 1497).

The U.S. National Slate Association explains grading as follows:

> With respect to the characteristics of slate, which have their effect upon grading, Dr. Oliver Bowles, Mineral Technologist of the U.S. Bureau of Mines says, in "The Characteristics of Slate" paper delivered before the American Society for Testing Materials, June, 1923:
>
> > "Slate is of medium hardness, very fine grained of low porosity, great strength and consists essentially of insoluble and stable minerals that will withstand weathering for hundreds of years. Some slate in Pennsylvania contains ribbons which consist of narrow original beds usually containing carbon and darker in color than the body. There is tendency for some ribbons to contain an excessive amount of the less resistant minerals and they should not appear on exposed surfaces."
>
> Some Pennsylvania slate contains ribbons and the output of some quarries in this district is divided into two classifications known as "Clear" and "Ribbon."
>
> The characteristics which are commonly accepted as affecting the appearance of the slate on the roof namely the surface, straightness, condition of the corners and thickness are used to determine the "Classification" or so-called "Grade" into which the quarries divide their product (Vermont Structural Slate Co., Inc., p. 10).

2.3 TYPES OF ROOFS

The following descriptions are based on the 1926 publication *Slate Roofs* by the U.S. National Slate Association.

2.3.1 Standard Roofs

Standard slate roofs are those composed of slate approximately $^3/_{16}$ in. thick (Commercial Standard Slate), of a standard length and width, having square tails or butts laid to a line.

> Slate of this type is commonly obtainable in the basic slate colors. Standard roofs are suitable for any building where a permanent roofing material is desired at a minimum cost. It differs from other slate roofs only in characteristics affecting the texture or appearance of the roof, through the shape and thickness of the individual units. If desired, the butts or corners may be trimmed to give a hexagonal, diamond or "Gothic" pattern for all or part of the roofs. …Standard roofs are sometimes varied by laying two or more sizes (lengths and widths) of commercial standard slate on the same area (Doney Slate Co., p. 5).

Standard Roof
(National Slate Assoc. 1926)

Textural Roof
(National Slate Assoc., 1926)

2.3.2 Textural Roofs

The term "textural" is used for those slates with a rougher texture than standard slates, with uneven tails or butts and with variations of thickness or size:

> In general, this term is not applied to slate over $^3/_8$" in thickness. Varying shades are frequently used to enhance the color effect, which, with the characteristics just mentioned, add interest in line and texture to the roof design. In addition to the basic colors of the commercial grades, accidental colorings of bronze, orange, etc., may also be used in limited quantities. (Doney Slate Co., p. 5).

2.3.3 Graduated Roofs

The graduated roof combines the artistic features of the textural slate roof with additional variations in thickness, size and exposure:

> The slates are so arranged on the roof that the thickest and longest occur at the eaves and gradually diminish in size and thickness until the ridges are reached. Slates for roofs of this type can be obtained

> in any combination of thicknesses from 3/16" to 1-1/2" and heavier when especially desired (Doney Slate Co., pp. 5-6).

Random widths should be used and laid so that the vertical joints in each course are broken and covered by the slate of the course above.

In 1927, besides the usual sizes, slates above 1/2 in. thick were produced in lengths up to 30 in. (Walker, pp. 1206-7)

2.3.4 Flat Roofs and Promenades

Flat roofs offer a wide field for roofing slate and are so designated whether or not they are used for "promenade" purposes.

Slate of any thickness may be used in place of slag or gravel as a surfacing material for the usually built up type of roof. Whether or not it is subject to the body, the weight and enduring qualities of slate make it highly desirable as a protection to the waterproofing beneath the surface (Only the thicker slates are used on promenades, according to the *Building Estimator's Reference Book* of 1927. For ordinary roofs the Standard 3/16 in. slate was ordinarily used but for promenade or extraordinary service, the slate would be 1/4 in. or 3/8 in. thick).

Slate for flat roofs were furnished in standard sizes of 6 in. x 6 in., 6 in. x 8 in., 6 in. x 9 in., 10 in. x 6 in., 10 in. x 8 in., 12 in. x 6 in., 12 in. x 7 in. and 12 in. x 8 in..

2.4 NAIL HOLES

The U.S. National Slate Association in 1926 recommended:

> No slate should have less than two nail holes. The standard practice is to machine punch two holes in all architectural roofing slate 1/4" and thicker at the quarry and also in commercial standard slate when so ordered. Four holes should be used for slates 3/4" or more in thickness when they are more than 20" in length. Holes are punched from one-quarter to one-third the length of the slate from the upper end and 1 1/4" to 2" from the edge. Where four holes are used, it is customary to locate the two additional holes about 2" above the regular holes.
>
> On normal thickness slates, no method of drilling has been developed which will produce the same clean hole as by machine punching (Doney Slate Co., p. 13).

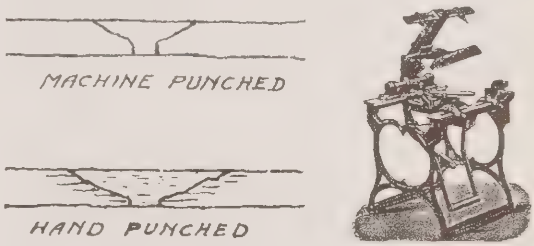
Fred Hodgson, in 1906, boasted that with a slate-holing machine:

> ...a smart boy, at 15 cents per hour, will be able to hole from 300 to 400 slates in an hour (Hodgson, p. 150).

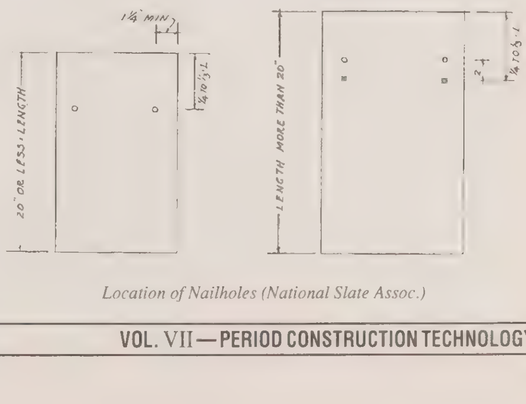
Other authors from the same period recommended:

> ...machine punching over hand punching, whether done at the quarry or on the job (International Library of Technology, p. 85).
>
> ....
>
> Formerly nail-holes in slates were punched on the job; now, however, slates are bored and countersunk at the quarry, when so ordered. Architects should always specify that the slates are to be bored and countersunk, as punching badly damages the slates (Kidder, p. 1497).

The term "hand punching" usually refers to the use of the double headed slate hammer which has one head in the form of a long prong. Hand punching of holes in fitting hips, etc., is necessary.



Machine for punching Nailholes (National Slate Assoc.)



Location of Nailholes (National Slate Assoc.)

2.5 FLASHING

The materials traditionally used for flashings are copper, tin, lead and zinc. Chabat in 1875 mentioned lead and zinc as flashing materials. Kidder mentioned tin, zinc and copper in 1914.

Durability of flashings is the first consideration when used with a material as permanent as slate. The most permanent non-ferrous metals and the best workmanship should be used.

2.5.1 Flashing Metals

The following information on flashing metals soldering and galvanic action is from the National Slate Association publication of 1926, *Slate Roofs*. This information was reprinted intact in 1953 and 1977.

a. Copper

Sixteen-ounce copper sheet is the minimum weight that should be used. Twenty-ounce sheet is preferred. Rain water mixed with dust and grit have an erosive effect on the metal. Flashing thickness should be enough to do the work of carrying away the water for a long period of time. The edges of all copper flashings to be soldered must be tinned 1 1/2" on both sides and the seams thoroughly and carefully sweated with solder. This operation is of utmost importance. Except on steep slopes (15° or over) all base flashing should be locked and soldered.

> Cap or counter flashings need not be soldered. The joint is made by lapping the sheets in the direction of the flow. When there is any likelihood of deep, wet snow packing in or of wind lifting the cap flashings, the joints should be soldered, using either locked or lapped seams. All exposed edges of flashings – such as the bottom edge of cap flashings – should have a 1/2" fold back under for stiffness against wind action. ...Copper requires no painting or other treatment unless it is desired to hasten the development of the natural green patina. In this case it is absolutely necessary that all the grease and oil used in the manufacturing process be removed from the copper. A strong soda solution (4 to 6 ounces per gallon of hot water) will do this. A uniform finish will not be obtained unless the copper is thoroughly cleaned. Copper can be painted provided the surface be thoroughly cleaned and roughened. This can be done by washing the copper with a solution of 4 ounces of copper sulphate in 1/2 gallon of lukewarm water in a glass or earthen vessel, to which has been added 1/8 ounce of nitric acid. Before painting, the surface must be carefully washed with clean water to remove the last trace of the solution (Doney Slate Co., pp. 27-28).

b. Tin

Tin used for flashings was called "terne-plate:"

> The base is of iron or steel and the coating a mixture of lead and tin put on the sheet by the hand-dipped... or Patent-roller process. The base metal recommended for flashings ...[weighs] about 62-1/2 pounds per 100 square feet. ...The lighter weight, or IC thickness, may be used but is seldom satisfactory. The weight of the base gives body to the metal, but its enduring qualities depend mainly upon the weight and thoroughness of the surface coating. ...tin is sold in sheets of various sizes from 10" x 14" to 20" x 28". ...IC tin is 30 gauge and weighs about 10 ounces per square foot (Doney Slate Co., pp. 27-28).

All joints should be securely locked and joints and seams thoroughly sweated with solder.

Always give the underside of tin one heavy coat of paint before laying as this protects the flashings from the effects of condensation. Clear off all grease and dirt and then give one coat of paint on the top side after laying. Metallic brown, Venetian red, red oxide or red lead may be used, mixed with pure linseed oil – not turpentine or a dryer. Apply a second coat to the surface two weeks after the first coat, then one or two additional coats to obtain the desired surface colour. Tin flashings should be repaired and repainted about every three years. Where dirt or leaves lodge and are retained on the flashings, it is advisable to remove any such accumulations and repaint at yearly intervals. Proper maintenance will add immeasurably to their life.

c. Lead

The use of lead for building purposes is an old practice that is now frequently desirable for flashings:

> It is unaffected by ordinary atmospheric conditions and its softness, pliability and malleability make it especially valuable in places where other materials cannot be easily introduced. Until the introduction

> of hardlead, the only lead available was softlead, which, while possessing many excellent qualities, was impractical for flashing because of its low physical strength. Hardlead has a much greater tensile strength which permits its use in comparatively thin sheets. Lead is protected by nature through oxidation of the surface upon exposure, and requires no further treatment (Doney Slate Co., p. 28).
>
> Hardlead is rolled in sheets 24", 30" and 36" wide and 6" long, weighing 2-1/2, 3, 4, 6 and 8 pounds per square foot. For gutter linings, cornice coverings, base flashings and roofing purposes generally, the 3-pound sheet is recommended and for cap flashings and batten roofs where the battens are spaced 18" or less on centers, the 2-1/2-pound sheet may be used.

Install lead so that it can expand and contract, never nailing directly through the sheet. The sheets should be fastened with cleats made of "16-ounce soft rolled copper or 3-pound hardlead, fastened to woodwork with two hard copper wire nails and to masonry with brass screws and lead shields. "The cleats should be spaced about 8" on centers, but on steep roofs continuous cleats for the horizontal joints are recommended."

> Where the edge of the metal is fastened by means of a reglet, there should be a continuous cleat of 3-pound hardlead caulked into the reglet and the sheet should be locked to the reglet. Never caulk the sheet into the reglet.
> Where the edge of the metal is unfastened, such as cap flashings and similar conditions where a lapped joint is provided, the free edge of the metal should be about 1/2 in.
>
> All nails should be hard copper wire flat-head nails not less than 3/4 in. long. All screws should be of brass and all shields of lead; iron or steel nails and screws, coated or uncoated should not be used. The sheets should be joined together by means of locked seams. Lapped and soldered seams are not recommended. Wooden tools should always be used in working and beating the material into place (Doney Slate Co., p. 28).

d. Zinc

Zinc has been used for roofing and general sheet metal work in Europe for more than a century, where its permanence and freedom from repairs have been thoroughly proven. Its use in North America has shown similar results.

> Zinc is a metal, not an alloy of other metals, which is extremely resistant to the corrosive action of the elements.
> It rapidly acquires a protective coating (a basic carbonate of zinc), which will continue to form as long as there is any raw zinc exposed. This protective coating gives the metal a light battleship grey color which will deepen with age and approach the color of grey slate. Zinc does not need paint as a protection, but paint can be readily used …if the other than natural color of zinc is desired (Doney Slate Co., p. 28).

According to the Doney Slate Company, rolled zinc for flashings should be not less than No. 11 zinc gauge (0.024" thick). It should be laid in the usual manner – not nailed, but held in place by zinc clips or cleats. "Zinc flashing against masonry, concrete and stucco should be laid on a good grade of water-proof sheathing paper. If the cap flashing is set in a reglet, it should be pointed with elastic cement" (Doney Slate Co., p. 30).

2.5.2 Soldering

The best grade of solder, composed of equal parts of new tin and new lead, should be used to joint pieces of metal into one length or sheet.

On copper, rosin is the best agent for this purpose. Rosin is harmless to the metal and makes good seams. "Rosin can be kept in place by "burning" it on with a small soldering copper just hot enough to melt the rosin." Acid flux can be used as a substitute, but only if it is properly prepared. The acid is hydrochloric or muriatic. Use acid on zinc and galvanized metal.

> Pieces of zinc are put in the quantity to be used until it stops working. If this "killing" is done hastily or by anyone not familiar with the procedure, the acid may be used in a still active state and attack the copper. The acid to be used for the entire job should be prepared several days before the work starts and allowed to stand. Where the joints of the metal are not thoroughly sweated or soaked with solder, they may be loosened by expansion or contraction of the metal or leave small holes in the joint through which moisture readily finds its way.

> A new product known as soldering salt may be used as a flux. It is claimed that these salts do not require so hot a soldering iron and that they also have other advantages (National Slate Association).

2.5.3 Galvanic Action

> Dissimilar metals, when in contact in the presence of an electrolyte, set up galvanic action which results in the deterioration of the most electropositive metal.
> Any possibility of galvanic action between copper and iron or steel should be carefully avoided by proper insulation. This insulation is effected in various ways, three of which are: (1) covering the steel member with asbestos, as is frequently done in skylight construction; (2) placing strips of sheet lead between the two metals, as when new copper gutters are placed in old iron hangers; and (3) heavily tinning the iron, as is often done with iron or steel gutter and leader supports. (National Slate Association)

2.6 NAILS

Most slate roof failures over a period of years may be attributed to improper punching of nail holes, improper nailing of slates or to the nails themselves. Properly laying and nailing slate is important and must be done by specially trained people.

> Before using nails, the Romans in England used wooden pegs to hold slate in place. They drove them through the slate and hooked them over the roof lath. The practice continued until after the middle ages when pegs, small leg bones of sheep and the tines of stags' antlers were used to hang the stone slates (Innocent, p. 177).

Late 19th-century and early 20th-century documents mentioned the different materials in wide use:

> Composition nails are best for all good work, as they are stiff and tough. They are cast from an alloy of 7 copper to 4 zinc and have a yellow, brassy appearance. Copper nails are either cast or wrought; but they are soft and dear. Malleable iron nails are frequently used, dipped while hot in boiled linseed oil to preserve them from corrosion. These can also be painted or galvanized. Cast-iron nails are only employed for temporary work. Zinc nails are very soft and liable to bend, they make a good deal of waste.
>
> All these nails are sold by weight and the price should lessen with the increase of length. Allow 5 per cent for waste in reckoning the number to the square (Hodgson, p. 149).

A detailed description of types of nails was noted in 1911:

> Nails. Slating nails have flat circular head, have a sharp point on shank and are made from 1-$^1/_2$ in. to 2 in. long. The five following materials are in general use for the manufacture of nails, viz., iron, zinc, copper, composition and lead.
>
> 1. Iron nails may be either cast or malleable. Cast nails resist oxidation better than the malleable, but being brittle are inferior to the above and are only used for cheap work. Malleable nails are first cast and then made malleable; they are often galvanized or painted to resist oxidation, but they are better when dipped while hot into boiled linseed oil, which method is frequently and successfully adopted. Iron nails are now not much used.
> 2. Zinc nails are, relative to iron nails, soft and easily broken, but with care they may be used without any appreciable waste and are very durable as they do not corrode. These are extensively used.
> 3. Copper. These may be obtained as wrought or cast, are very soft, relatively expensive, they are non-corrosive and are only used in very good work.
> 4. Composition. These are a mixture of zinc, copper and tin. The alloy is much harder than either the copper or the zinc; does not oxidize to any extent and is better adaptable for driving. They should be employed on all important work.
> 5. Lead. These ... are similar to the ordinary slating-nails and about 4 inches in length. They are used for securing slates direct to iron battens. The nail is passed through the hole and is bent about the small tee or angle iron batten. They are sometimes used for boiler houses and similar work, where a great measure of fire resistance is of more consequence than appearance (Mitchell).

The following information is a summary on nails for slate roofs taken from National Slate Association publications.

> It is the practice in some localities today to hang the slate to the laths or battens by means of heavy wire hooked through the slate and over the laths. This method is in general use where the slate is laid directly on steel construction.

Nailing is used more extensively today than other methods for securing the slate. The important considerations involved are shape, size and material.

The ordinary diamond point and smooth shaft are sufficient for a slating nail and the needle point is seldom necessary. The shaft, since it supports a greater weight and must resist a small shearing stress, should be larger than that of the shingle nail. To prevent the slate from being lifted up over the nail after being laid, the diameter of the head should be greater than that of shingle nails.

Copper is one of the most enduring of metals; iron and steel, adequately protected from corrosion by a heavy coating of zinc applied by the hot-dipped process, will give reasonable service. Plain or ordinary galvanized nails should not be used for laying slate.

Chrome-iron alloy nails and other types are particularly suited to resist atmospheric corrosion. Their cost is higher than copper, yet for certain buildings with excessive or unusual acid fumes under and surrounding the slate roofs, it may prove economical to use such nails. When cost is an item, the "copperweld" nail, being less expensive than solid copper, is often used and may prove to be the satisfactory method of protecting the steel shaft.

It is common to use 3d nails for commercial standard slates up to 18 inches long, 4d nails for the longer slates and 6d on the hips and ridges. Thicker slates require longer and heavier gauge nails. The proper size may be determined by adding 1 inch to twice the thickness of the slate. Where the underside of the roof boards is exposed to view, as is sometimes the case with overhanging eaves, a nail should not be driven through the sheathing.

Nails suitable for roofing purposes are four types; each has its own advantages:

The common wire nail is used generally for nailing flashings, sheathing and sometimes for shingling. It is not suitable for slate work, for it is light gauge and has a small head.

The slating nail is especially adapted for slating, as it is of heavy gauge and has a wide, flat head. These features make it much more desirable than the common wire nail.

The roofing nail is not recommended. While the shaft is of proper thickness, its head is too small.

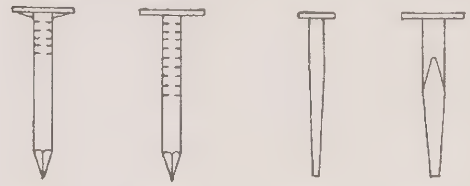


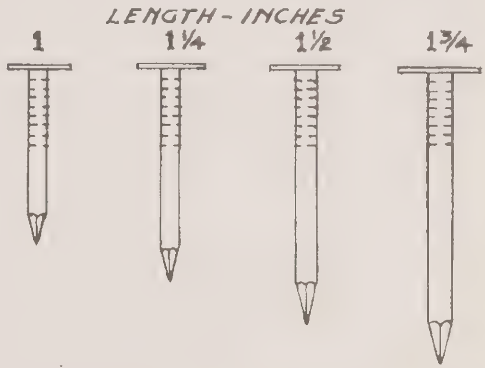
Figure 29 Copper Wire Nail. (Similar to Steel Wire Nails)

Figure 30 Large Flat-Head Copper Wire Nail. (Slating Nail)

Figure 31 Regular Cut Copper Nails

Figure 32 Large Flat-Head Cut Copper Roofing Nail

[Note difference in head of ordinary wire nail (Figure 29) and large flat-head wire nail (Figure 30)].



The cut nail is made from sheets and is of quite different shape than any of those made of wire. The enlargement of the shaft gives it more stiffness than the wire nail has, but there is some danger of splitting the slate if too large a nail is used.

A 1977 publication by the Vermont Structural Slate Company suggested using threaded nails of copper alloy or commercial bronze alloy.

2.7 FELT

Where heat insulation is not required a standard slate roof can be laid watertight on open lath without felt:

> Stone slates and tiles were formerly bedded on vegetable materials, such as hay and straw, a survival, probably, of the roof covering of the earliest buildings: this method had also the practical advantage of covering the joints of the slates or tiles and helping to keep out the weather. In many districts moss was used, which was not the ordinary moss which grows on walls, but long bog-moss ...found on the sea shore at high water mark ....
>
> The mossing of roofs was a special trade, and in North Wales the man who went round periodically was called, in Welsh, the moss man and the slates themselves were known as moss stones ....
>
> The original moss decayed in the course of time, and the mosser obtained his living by poking up new moss under the slates, to keep out draughts and snow: in Derbyshire this was done with a square ended heavy trowel known as a mossing iron. Mossing is now obsolete in Derbyshire, and the stone slates are pointed with mortar, in the same manner as the Welsh slates. In the years 1477-78 the church wardens of St. Michael's, Bath, bought 'pack moss'....
> (Innocent, p. 181)

In the 15th century, hay and straw were bought to be laid under the slating of St. Peter's Church, Oxford.... in some parts of Surrey the practice of bedding roofing tile on clean straw is still followed, but not for better class work .

The Architects and Builders' Pocketbook, in 1914 mentioned bedding materials of tarred paper, waterproof paper and felt (Kidder, p. 1497).

Sheathing felt, however, was mentioned in a 1909 publication, *Roofing:*

> The sheathing felt should be applied parallel to the caves, if possible, but if the roof is steep it may be laid at right angles to them. In either case it is lapped 2 inches and fastened to the roof with nails having large flat heads (International Library of Technology, p. 85).

National Slate Association recommendations can be summarized as follows:

Roofing felt has distinct uses in connection with slate roofs. Placing the felt as soon as the roof is sheathed will protect the building until the slates are laid. It has considerable insulating value inside during winter and summer months. The use of laths over the felt and under the slates to obtain an air space, a method recommended by English roofers, adds much to the insulating value of the felt. The other use of felt is to form a cushion for the slate. Its value in this respect increases with the thickness and weight of the slate.

For the commercial standard slate, felt weighing 14 pounds per square is satisfactory. For graduated roofs, the 30-pound weight is commonly used when the slates are 3/4 in. or less in thickness and the 50 pound for slates 1 in. or more. It is customary in some localities to place two layers of felt under the slate of a graduated roof. The first layer is usually 30 pound felt and the second 14 pound. This provides an extra cushion for the heavy slates. The joints and laps should always be staggered.

> The felt should be laid in horizontal layers with the joints lapped toward the eaves and at the ends. A lap of a least 3" should be used and the edges well secured to the surface over which it is laid. A lap of not less than 2" should be used over the metal lining of valleys and gutters. If metal other than copper is used as a lining, the felt should be omitted in the valleys. Extend the felt over all hips and ridges at least 12" to form a double thickness.
>
> Asphalt-saturated rag felt should always be used. The so-called "Slaters'" felt includes many types of materials which cannot be recommended (Doney Slate Co.).

2.8 ELASTIC CEMENT

The National Slate Association, 1926, stated the purpose of using elastic cement:

> Elastic Cement ...is used under slates forming hips and ridges to help hold securely in place those slates which are usually smaller than the regular roofing sizes and which cannot be so well nailed. Elastic Cement is also used for pointing the peaks of hips and ridges (Doney Slate Co., p. 24).

At the turn of the century mortars were used for the above-mentioned purposes; however, there is a mention of "slater's cement" in 1909 as being composed of paint skins and refuse lead (International Library of Technology, p. 91). Another publication described the material:

> Torching is the pointing from the inside of slating with hair-mortar, to keep out draughts and driving rain. Shouldering is the bedding of the heads of slates for about two inches with hair-mortar mixed with coal ashes to obtain a slatey colour, for the purpose of keeping tightly down the tails of slates. Rendering is the bedding of slates in hair-mortar upon a firm ground, to give the slates a firm bed and to permit of traffic upon them (Mitchell, p. 406).

Later in 1915, elastic cement was mentioned in the *Architects' and Builders' Pocketbook:*

> **Elastic Cement**. In first-class work, the top course of slate on the ridge, and slate for from 2 to 4 ft. from all gutters and 1 ft. each way from all valleys and hips, should be bedded in elastic cement (Kidder, p. 1498).

The National Slate Association also points out that in some localities experienced roofers abandoned the use of elastic cement and still created absolutely watertight roofs. In certain locations on the roof, the use of cement may even prove to be detrimental rather than helpful. This happens to under slates adjacent to open valleys where the cement may dam the water and force it back under the slates instead of permitting it to run out into the valley.

When elastic cement is used, it should be waterproof and have a high melting point and a low freezing point. It should not dry out when exposed to the air. The best grades of cement are oily and sticky. Considering the small amount ordinarily required for a slate roof, it is economical to use the best available.

The elastic cement should match as nearly as possible the colour of the slate, keeping in mind that certain colours of slate may fade upon exposure (National Slate Association, p. 24).

2.9 SLATER'S TOOLS

The National Slate Association, in its 1926 publication, listed slaters' tools as being the punch, hammer, ripper and stake. If punching is not done at the yard, a punching machine is needed besides the hand or mawl punch. The slaters' equipment is completed with tinner's snips, rule and chalk line.

An approved hammer is forged solid, all in one piece, from crucible cast steel, with an unbreakable leather handle 12 in. long to avoid slipping and blistering the hands. "One end terminates in a sharp point for punching slate, the other in the hammer head. There is a claw in the center for drawing nails, and on each side of the shank there is a shear edge for cutting slate. The head, point and cutting edges are properly tempered to withstand heavy work." Left-hand hammers and special hammers can also be obtained from distributors of roofing slate or manufacturers of such tools.

"The ripper is about 24" long and is forged from crucible cast steel. It is used for removing broken slate and making repairs. A hook on the end provides a means for cutting and removing the slating nails. The blade is drawn very thin and the hook end correctly tempered for hard wear." Shorter rippers are also available.

The stake is about 18" long and T-shaped. The long edge is used as a rest upon which to cut and punch slate or as a straight edge to mark the slate when cutting and fitting around chimneys, hips, valleys, etc. The short arm is tapered and pointed for driving into a plank or scaffold. Stakes 24" long are also available. The hand or mawl punch is forged from fine tool steel-hardened and ground about 4 1/2" long, with one end tapered. The butt end is struck with a mawl to punch the nail hole.

A punching machine should be used for punching the nail holes and cutting the slates. It is adjustable to any size or shape and cuts and punches at one operation with a countersunk hole.

The scaffold bracket which supports a plank creates a working platform. It hangs by straps from the ridge or rests on an adjustable support.

A description of slaters' tools in 1911 included the same tools mentioned above with the addition of "the iron straightedge":

> 1. The sax (equivalent of "stake"; also known as zax) is used for trimming the edges and holing the slates.
> 2. The iron straightedge is used for trimming slates and is fixed to the edge of the bench or block by means of screws or sharp iron points projecting from the underside. Another tool similar to the dog used in rough carpentry work is sometimes used on work

in progress in place of the iron straightedge, as it is easier to fix, being driven into any convenient plank.
3. The hammer with hammer face at one end and sharp point at other for holing, with a projection from side with slot for drawing nails.
4. The ripper is a thin steel blade about 2 feet in length, provided with a handle; the other extremity is flattened out to a semi-circular shape and has three slots as shown in figure 1106; it is used for removing broken slates, the nails being cut by the slotted semi-circular end (Mitchell, p. 409).

When cutting slates, they are laid on an iron straightedge or cutting-dog and the edge is trimmed with a zax. The face in contact with the iron straight edge is true and regular, but the

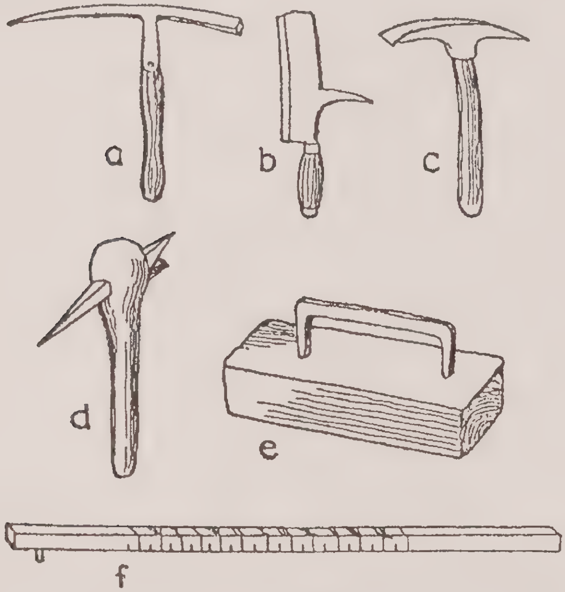
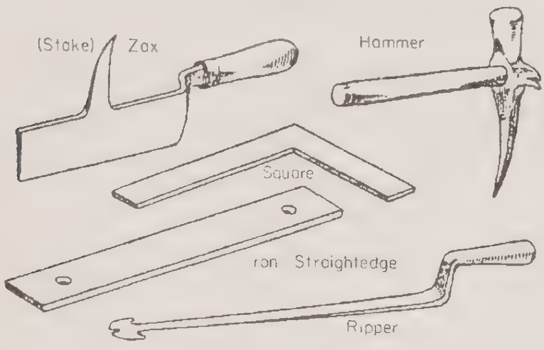


Fig. 134. Slater's tools: (a) Slater's pick. (b) Saxe, or zax. (c) Slatting hammer. (d) Slat pick, or pittaway. (e) Dressing iron. (f) Slater's rule.

Slater's Tools (after Davey)

upper surface is jagged and rough.

> In the year 1688, according to R. Holme, the slater's tools were as follows: Hatchet, Trowel, Hewin g Knife, Pick to Hole, Pinning Iron to widen the holes, Hewing Block, Lathing Measure and Stone Do., and Pins, Stone Hails or Lath Nails and Lath or Latts (Innocent, p. 177).



after Mitchell

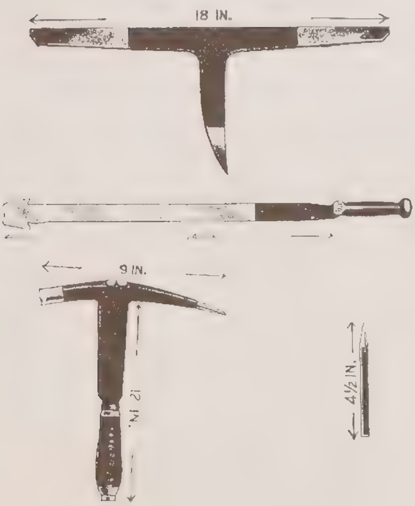


Figure 28. Slater's Tools

Slater's Tools (after Davey)

3.0 FIELD PRACTICE

3.1 ESTIMATING

What information there is on the preparation of 18th- and 19th-century slate roof estimates comes mostly from turn-of-the-century handbooks and guides produced for carpenters, contractors, builders, etc. In the absence of first hand accounts, this is the only indication of what techniques earlier tradesmen were using for estimating their roofing materials.

3.1.1 Quantity

Common to almost every estimate was a bill of materials – a breakdown of the components making up the job, properly described, listing the required quantities and possibly the unit prices. Roofing materials were generally broken down as follows: timber items, roof boards, laths, tilting fillets and slates, hardware items, nails and screws, sheet metal items, flashing and ridge rolls.

Quantities for individual roofing materials were calculated using various roof measurements. Roof area, by far the most important, was obtained in either of two ways: precise actual measurements of roof areas (using drawings or taking on-site measurements) or applying a rule-of-thumb adjustment to known ground area measurements. Suggestions on how to calculate roof area were abundant.

Various methods for determining lath or roof sheathing quantities were offered by the guides and handbooks. All, of course, depended on the roof area calculation described above. These calculations were similar to those provided for shingle roofs (see Section 9.1 "Shingle Roofing").

3.1.2 Nails

Hodgson's Estimator and Contractor's Guide mentioned that the number of slating nails required per square will be found by doubling the number of slates because each slate takes two nails. Some publications provided a table that specified sizes of nails needed for different slate sizes. The table also showed the different kinds of nails available in that period and their cost.

> Nails for small slates, such as Doubles, etc., should be about 1-1/4 in. long
>
> Nails for medium slates, such as Countesses, etc., should be about 1-1/2 in. long
>
> Nails for large slates, such as Duchesses, etc., should

be about 2 in. long

Slate nails

Galvanized slate nails, per keg, 3d	\$5.50
Galvanized slate nails, per keg, 4d	\$5.50
Tinned slate nails, per keg, 3d	\$5.75
Tinned slate nails, per keg, 4d	\$5.25
Polished steel wire nails, 3d and 4d	\$4.00
Copper slate nails, per pound 20	

These prices vary with time and locality (Hodgson, p. 149).

Weights for slating nails were mentioned in 1881:

Composition

1 1/2 in. long	=	5 lbs.	15 oz.	per 1000
1 3/4 in. long	=	8 lbs.	1 oz.	per 1000

(Spon, p. 229).

Other tables are provided below for the sizes, length, weight and number of nails per pound.

3.1.3 Slate

Slate is sold at the quarry on the basis of the quantity required to cover 100 sq. ft. or a "square" of roof when slate is laid with a 3 in. head lap. If the roof is flat or other than 3 in. lap is used, the quantity must be corrected to the equivalent amount as though the 3 in. lap were used. In estimating the net quantity, allowance is made for additional material required around chimneys, dormers, hips, valleys, etc. This method was mentioned by the National Slate Association in 1926. Architects' and builders' handbooks around the turn of the century provided tables for estimating the number of slates in a "square" for the different sizes of slates.

In measuring slating, the method of determining the number of slates required per square is similar to that given for shingling, but in slating each course overlaps only two of the courses below, instead of three, as in shingling. The usual lap or cover, of the lowest course of slate by the uppermost of the three overlapping courses, is 3 in., hence, to find the exposed length, deduct the lap from the length of the slate and divide the remainder by two. The exposed area is the width of the slate multiplied by this exposed length and the number required per square is found by dividing 14 400 by the exposed area of one slate.

Thus, if 14 in. x 20 in. slates are to be used, the exposed length will be:

$$\frac{20 - 3}{2} = 8\tfrac{1}{2}\text{ in.}$$

and the number required per square will be 14 400 minus 119 = 121 slates.

The following rules should be observed in measuring slating:

Eaves, hips, valleys and cuttings against walls are measured allowing an extra 1 ft. wide by their whole length, for waste of material and the increased labour required in cutting and fitting. Openings less than 3 sq. ft. are not deducted and all cuttings around them are measured extra. Extra charges are also made for border figures and any change of colour of the work and for steeples, towers and perpendicular surfaces.

Similar rules for estimating were given by the National Slate Association in their 1926 handbook.

Tables of weights per square foot were sometimes provided:

Weight of slate per square foot

Thickness Inches	Weight Pounds
1/8	1.82
3/16	2.73
1/4	3.64
3/8	5.46
1/2	7.28
5/8	9.06
3/4	10.87
1	14.50

(International Library of Technology.)

3.1.4 Flashing

There are no methods for estimating flashing mentioned in 19th- and 20th century North American handbooks. However, attempts were made in some English handbooks to estimate flashing as part of the plumber's work – the plumber being literally a person who worked with lead. Apparently plumbers were involved in this trade late in the last century.

The National Slate Association in the U.S. recommended a method of estimating developed by one contractor. This rule considered that flashings for hips and valleys are bent diagonally from corner to corner, while those for cheek or side walls are bent lengthwise, allowing 4 in. to turn up on the side wall and 4 in. flashed under the slates.

3.1.5 Cost

In 1926, according to the National Slate Association, a good roof would normally account for six percent to eight percent of the total cost of an average building. This included costs from the time work was started at the quarry until the material was laid on the building:

- cost of slate punched or unpunched
- transportation to storage yard and/or construction site
- storage and waste at storage yard and/or construction yard
- laying slate on roof including roofing felt, elastic cement, nails, sheet metal, snow rails, labour, waste and contractors profit

The cost estimate of a slate roof would depend on:

- quantity of slate
- kind and colour of slate
- sizes of slate, stating "uniform" or "random"
- thickness, stating "commercial" ($^1/_4$ in., $^3/_{16}$ in.) or other thicknesses
- kind of nails, zinc, copper, etc.
- kind of flashings
- kind of roof, valleys, hips, gables, etc.
- kind of snow guards and snow rails
- location of the construction site
- deadline on the execution time.

Architects' handbooks sometimes provided a breakdown of the cost for one square of slating.

3.2 STORAGE

Storing slate in a storage yard or at the construction site is done by piling it in a certain way on a good base.

The earth foundation should be solid, level and dry. Wood planks 2 in. thick can be laid on the ground to keep slates from contact with the earth and to distribute the load evenly.

> The first tier should be started by laying one pile of slates flat to a height equaling the width of slate being piled; i.e., for 20" x 12" slate the flat pile is 12" high.
>
> The following slates of the first tier are placed in an upright position on edge lengthwise, and should be kept as straight and vertical as possible. The bottoms of each handful should be tight against the bottom of the preceding slates. In this way the top is maintained straight and level.
>
> After the first tier has been laid to the desired or a convenient length, lay a double row of wooden lath lengthwise over the top of the first tier. Place the lath 1" from the outside edges of the slate tiers and interlap each lath one or two inches. A liberal quantity of straw may be used as a substitute for the lath.
>
> Rest the flat or starter of the second tier one half on the first tier starter and one half on the upright slates. This will help to prevent the piles from overturning and "slumping" down obliquely. Keeping the following slates as nearly perpendicular as possible is especially important in the first two tiers.
>
> Slates up to and including 20" x 11" may be safely piled up to 6 tiers high. Slates of a larger size should never be piled more than 4 tiers high. Closely piled, 100 commercial standard slates average 20" to 24".
>
> When the slates are stored in an open yard, cover the piles with overlapping boards or use tar paper weighted down. Adequate protection prevents the slates from being frozen together. While slates are of ample strength when used in their proper place, reasonable care should be used in the handling of the material (Doney Slate Co., p. 46).

Another source on storing and piling slate described the same method:

> Sorting and piling slates preparatory to laying is a most important detail of the roofer's work. Slates should be piled with their edges up, the pile in no case being more than 3 feet 6 inches in height; the ends of the tiers may be held up by laying a pile of slates on the flat, while the top of the pile should be covered with slats laid flat, to keep out moisture. The slate should be sorted or selected by grades of thickness, the thin slates being piled first and the thicker ones next. Thick slates should be laid on the

lower part of the roof and the thinner ones at the top (International Library of Technology.).

3.3 PREPARATION OF ROOF DECK

The National Slate Association stated that roof construction which conforms to good engineering practice will be suitable for slate roofs of commercial standard thickness slates. It pointed out that the weight of the slate is insignificant when compared to the dead and live loads to be considered when designing a new roof or repairing an old roof. Weights of slate roofing average 7 pounds per square foot compared to 2 $^{1}/_{2}$ lb. /sq. ft. for wood shingles and 14 lb. /sq. ft. for clay tiles.

The same publication provided tables for allowable unit stresses for structural timber, strength of rafters and rafter sizes for roofs of any size. It also mentioned that *Kidder's Architects' and Builders' Pocketbook* gave slate a snowload credit of 3-12 pounds per square foot over shingles, depending upon the slope of the roof and the climate.

It is important that structural members are well tied together at the joints of wall plates with rafters, purlins or joists. A wood plate on top of a masonry wall should be bedded in mortar and anchored to the wall. Using a ridge board is preferable to butting rafter peaks, because it will provide a straighter ridge for roofing.

3.4 SHEATHING OF ROOF BOARDS

Mitchell, in 1911, gave a comprehensive description of the sheathing methods for slate roofs:

> 1. Wood Battens – Nailed horizontally across rafters fixed to the required gauge.
> 2. Close Boarding – The rafters are boarded over and the slates nailed direct to the boards; this is a better method than battening.
> 3. Close Boarding and Asphalted Felt – The felt is a non-conductor and prevents radiation and thus preserves a more equable temperature in the interior of buildings; it is also waterproof and therefore forms an extra precaution against damp.
> 4. Close Boarding Felt and Battens – Where the slates are laid direct on the felt, the latter is liable to decay from want of ventilation; to prevent this, battens are laid horizontally on the felt to which the slates are fixed, thus allowing a circulation of air over the surface of the felt.
> 5. Close Boarding, Felt, Vertical and Horizontal Battens – The last method is open to the objection that should any water find its way between the slates, as in the case of a broken slate, the water would lodge upon the horizontal battens and cause them to rot. To avoid this, battens are first laid on the felt to the slope of the roof and fixed one over each rafter; horizontal battens are nailed to these again and then the slates, so should any water get beneath the slates it can run away. This leaves a larger air space, which is better for ventilating the battens and felt, also for preserving the temperature inside the building. This method should be adopted on all monumental buildings and on roofs not easily accessible (Mitchell, p. 401).

The National Slate Association recommended open battens or lath only for barns or outbuildings. It suggested close boarding with tongue and groove boards of even thickness, 6 in. to 10 in. wide. When lath is used, it is spaced so that the nail holes are over one lath and the top edge of the slate over another.

In *Architectural Construction*, other alternatives were mentioned:

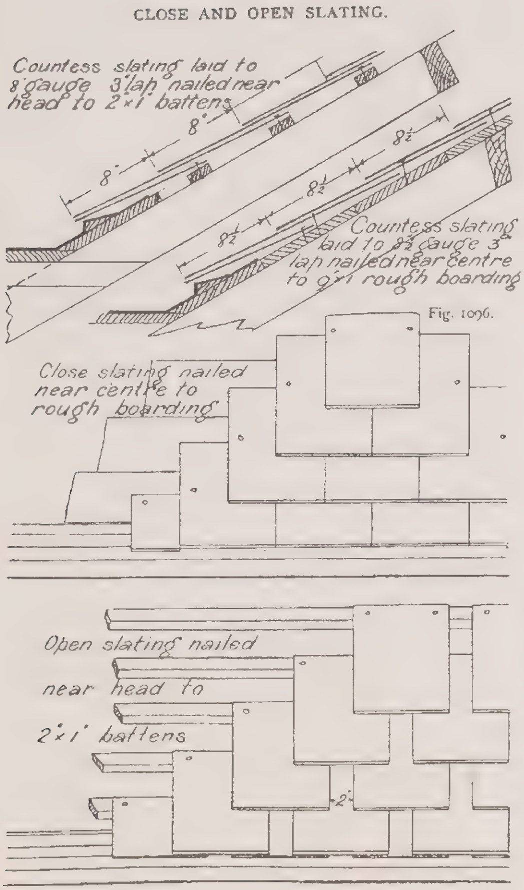
> Marched roofing boards are nailed over the rafters in wood frame construction and covered with asphalt roofing felt. In fireproof construction wood nailing strips are embedded in the slabs or porous terra cotta or nailing concrete is introduced to receive the nails (*Architectural Construction*, p. 199).

3.5 LAYING SLATE

According to the National Slate Association, slate is a lasting roofing material that should be laid by experienced roofers to avoid mistakes and thus eliminate the need for repairs almost indefinitely. There are some considerations to be taken into account in laying slates:

a. Slates should not be so rigidly held in place as to shatter around the nail hole. This might cause the slate to ride over the nail and come loose in a heavy wind.

   The nailing of wooden shingles and slates are entirely different. "The heads of slating nails should just touch the slate and should not be driven "home" or draw the slate, but left with the heads just clearing the slate so that the slate hangs on the nail" (Doney Slate Co., p. 14).



Close and Open Slating (National Slate Assoc.)

b. Nailing should be through the solid parts of sheathing, avoiding the joints, especially near the ridge of the roof.

c. The joints of the different materials laid on one roof should be broken so that no through joint can form from roof surface to the felt.

d. Slates of an overlapping course should be jointed on the centre of the under slates by starting every other course with a half slate or a slate that is one and one-half times the width of the others. When random width slates are used the joints of the overlapping course should be as near the centres of the under slate as possible, but not less than the standard 3 in. lap from under joint.

"With few exceptions, the standard 3 in. lap should be insisted upon. ...The small saving in slate through reducing the lap will not compensate for the risk entailed due to the lessened amount of material over which water might flow" (Doney Slate Co., p. 15).

e. A slater's stake should not be driven into the roof board lest it damage the roof felt. A plank should be used for this purpose with the stake driven into the scaffold only.

f. Metal straps used occasionally by slaters to support scaffold brackets are later cut off and the parts remaining on the roof rust over time. This practice should be discouraged.

Laying Slate (National Slate Assoc.)

3.5.1 Lap and Exposure (Gauge)

Sloping roofs having a rise of 8 in. to 20 in. per foot of horizontal run should be laid with the 3 in. lap. For steeper roofs, such as the mansard and others nearly vertical in plane, a 2 in. lap usually will be sufficient. In some places it is customary to increase the lap to 4 in. when the slope is from 4 in. to 8 in. per foot, while in other parts the 3 in. lap is considered entirely adequate. Flat roof construction should be used for slopes less than 4 in. per foot. For vertical walls or siding 2 in. lap would be sufficient.

The "exposure" of a slate is the portion not covered by the next course of slate above and is thus the length of the unit exposed to the weather. The standard "lap" of the alternate courses used on sloping roofs is 3 in. and is the basis upon which all roofing slate is sold and the quantity computed. The proper exposure to use is then obtained by deducting 3 in. from the length of the slate used and dividing by two. For instance, the exposure for a 24 in. slate is 24 in.-3 in. ÷ 2 = 10 ½ in. exposure.

Exposure in inches for sloping roofs

Length of Slate in Inches	Slope 8" to 20" per foot, 3" lap
24	10 ½
22	9 ½
20	8 ½
18	7 ½
16	6 ½
14	5 ½
12	4 ½
10	3 ½

Mitchell presented calculations for exposure and position of nail-holes:

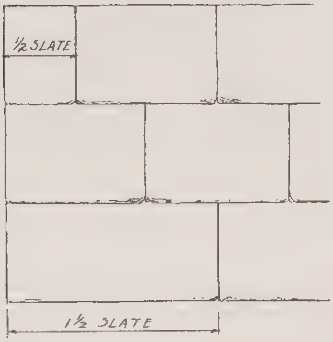
> Gauge for Nailing Slates near the Head – In this method of fixing slates, the nail holes are placed one inch from the head. The calculations to ascertain the gauge are as follows: – One inch plus the lap is deducted from the total length of the slate, the first being due to the material above the nail-hole not being included in the lap and the remainder is divided by two, which will give the gauge and may be stated thus:
>
> $$\text{Gauge} = \frac{\text{length of slate-1"-lap}}{2}\text{, which In Duchess}$$
>
> Slates would be:
>
> $$\frac{24\text{-}1\text{-}3}{2} = \frac{20}{2} = 10 \text{ inches}$$
>
> Gauge for Fixing Slates near the Middle – The gauge is determined as follows: – The lap is deducted from the length and the remainder is divided by 2 and may be stated thus:
>
> $$\frac{\text{Length of slate-lap}}{2}$$
>
> In Duchesses would be $\frac{24\text{-}3}{2} = 10\ ^1/_2"$
>
> The slater determines the position of the nail-hole in the following manner: the lap is added to the gauge and ½ inch for clearance is allowed, measurements being taken from the tail. It may be stated thus: Gauge + lap + ½ in. = distance of nail-hole from tail. In Duchesses would be 10-½ + 3 + ½ = 14" The distance of nail-holes from the long edges in either method is 1-¼ inch.
>
> Slates that are nailed near the head always have two thicknesses of slate over every nail-hole and the lap is practically 1 inch more than that which is calculated if the portion above nail-holes is taken into account. But as this method requires more slates, it is therefore more expensive; and the long distance the nails are fixed from the tail allows the wind to act with a greater leverage, which, in bad weather, sometimes strips the roof.
>
> It can thus be observed that fewer slates will be required to cover equal areas of similar roofs by the method of nailing at the middle, than by the method of nailing near the head (Mitchell).

3.5.2 Slope of Roof

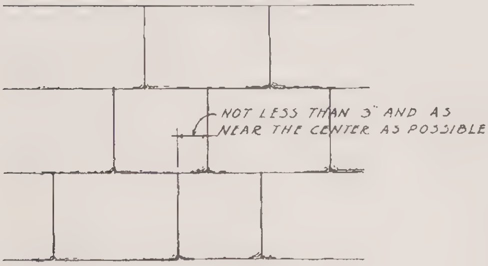
The slope of a roof has been defined as the angle of inclination that the roof makes with a horizontal plane. The National Slate Association in 1926 provided a diagram showing the effect of this slope on the lap of the slate.

Slope is dependent upon climatic conditions and the design and determines the method of laying the slate and the lap required

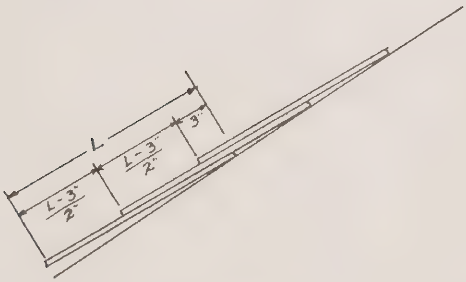
Kidder mentioned in 1915 that roofs to be covered with slate should have a rise of not less than 6 in. to the foot for 20 in. or 24 in. slates or 8 in. for smaller sizes .



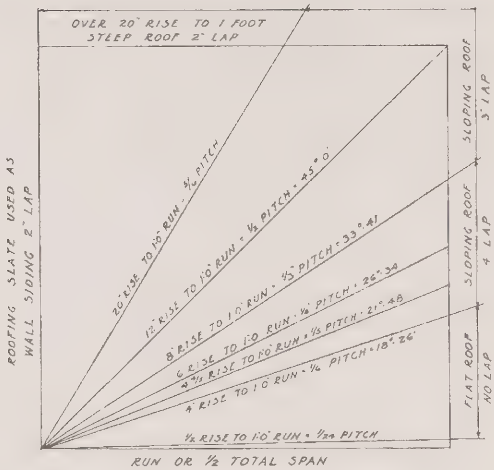
Starting Slate



Proper Jointing



Lap and Exposure
(National Slate Assoc.)



Lap of Slate for Various Roof Slopes (National Slate Assoc., 1926)

3.5.3 Methods of Laying Slate

There were few methods of slating mentioned in architects' and builders' handbooks and literature at the turn of the century. Common to all methods, however, was the following description mentioned in the International Library of Technology text on roofing in 1909. In commencing to slate, the first course is laid double, the lower or undereaves course being laid with the back of the slate next to the boards; the length of the slates in this course will be equal to the gauge plus the lap and should project over the eaves or gutter edge from 1 ½ to 2 inches. All the courses must be laid with broken joints; the last course is known as a finisher and is put on to receive the ridge roll.

Where all slates are one width, slates should be jointed at the centre of the slate beneath by starting every other course with a half slate or, where available and practicable, a slate one and one-half times the width of the others.

Where random widths are used, the overlapping slate should be jointed as near the centre as possible and not less than 3" from any under joint.

> Slates should be laid with their tails horizontal, but wherever taper-shaped gutters occur, the side of the gutter nearest the ridge is not parallel with it, so the tails of doubling courses form an exception to this rule.

Mitchell in 1911 stated that, in all slating methods, "tilting fillets" should be used to enable the tails of slates to fit closely against the slates below and to form a close joint to keep out wind and wet. A tilting fillet or springing piece, as it is sometimes called, must be nailed under the tail of the first slate or doubling course. This will give all the slates a tilt and cause them to bend on their tails. The slates will consequently be slightly apart – the less the distance apart the better – so that during repairs they are less likely to be broken. The tilting pieces are about $^1/_2$ to $^3/_4$ in. thick by 3 in. in length and tapered.

When roofs are battened, instead of a separate tilting piece, the first batten may be 1 $^1/_4$ to 1 $^1/_2$ in. thick and tapered.

Tilting fillets are also used against chimney breasts, to guide water away from walls or at ridges, to compensate for the tilt of slate lost by its length being shorter than others or in any position where slates are desired to be slightly raised (Mitchell, p. 89).

a. Dutch Lap Method

The Dutch lap method was defined in the National Slate Association publication of 1926 as: laid with regular slate on shingle lath or tight sheathing.

b. Open Slating

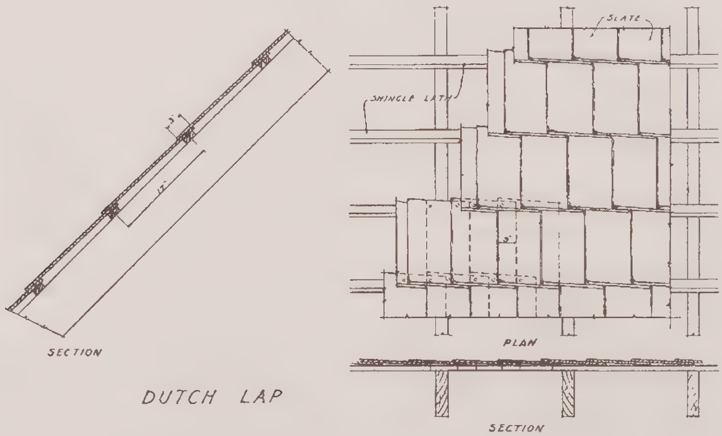
The "open slating" or "half slating" method was also mentioned by the International Library of Technology text in 1909 as sometimes used where economy of material was required. The lower courses should be laid double, following the standard method. The courses above this have a space between the edges of the slates equal to one-half the width of each slate. The whole surface is thus laid up to the ridge; the last course or finisher and the ridge roll are completed as for other roofs.

Half slating, when laid on battens, should be used only when a perfectly tight roof is not necessary. However, when laid on boards covered with felt, it makes a good serviceable low-priced roof. This method is especially suitable for barns and buildings where ventilation is desirable or in mild climates.

c. French Method

The French method of laying slates, according to the above mentioned publications, had become popular in New England for new roofs or for re-roofing over old temporary roof coverings, because it was less expensive than the standard method. It is also called diagonal or hexagonal slating. In this method, slates are applied on a solid roof deck of sheathing or roof boards. Heavy asphalt-saturated felt is applied on the sheathing to conserve heat. Sufficient lap of approximately 3" must be provided.

The 14 in. x 14 in. size is used for houses and buildings with larger gables and sections, while the 12 in. x 12 in. size is used on smaller buildings. Only certain quarries stock slate for this method (National Slate Association, p. 70).

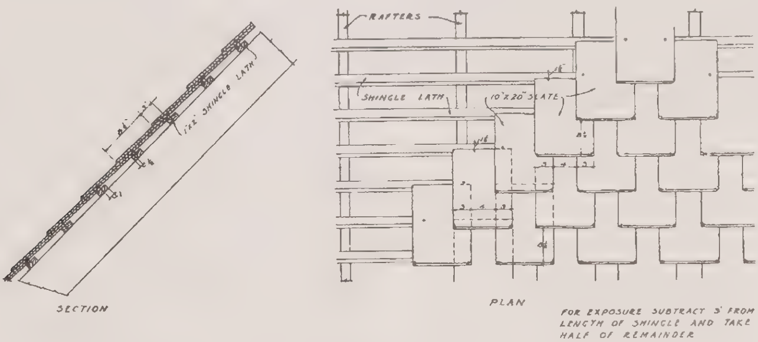


Dutch Lap Method (after Ramsey & Sleeper)

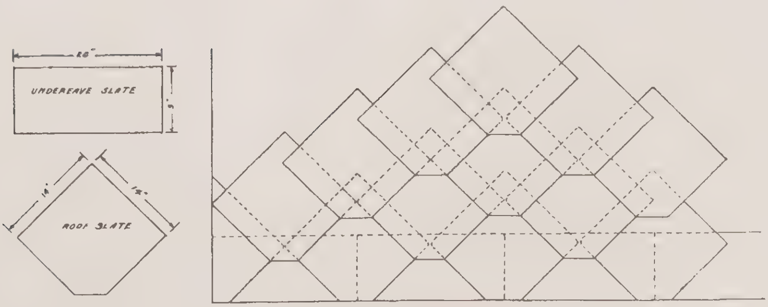
d. Old English

A fourth method of slating – Old English – was mentioned by Kidder. This involves using different shades of coloured slates in graduated courses and in random widths beginning at the eaves, for example, with slates 28 in. long and 1 1/2 in. thick and using the different thicknesses from 1 1/2 to 3/8 in., in shorter lengths, in working upward on the roof. The method possesses vast possibilities for carrying out architects' ideas for varied artistic effects.

> The slates are made with rough-cut edges in all thicknesses from 3/16" to 1 1/2", in a combination of various shades carefully selected in such proportion as to produce the best possible harmony when laid. As all of these colors and shades are unfading, the WEATHERED effect is obtained at once and is permanent. ...The Old English color-combination roofing-slates should be specified to secure the light-and-shadow effect, and it is of the utmost importance to specify the thickness desired, ...cost varies according to thickness. ...the thickest slates are used in the largest sizes [up to 36" in length], [at the eaves].... Among the good specimens of the Old English style of roofing may be mentioned the buildings of Princeton University for the Graduate College, where different shades of unfading-green slates are used in thicknesses running from 1 1/4 in. at the eaves to 3/8 in. at the ridge (Kidder, p. 1498).



OPEN SLATING
FOR USE WHERE VENTILATION IS DESIRABLE



FRENCH METHOD
ALSO KNOWN AS "HEXAGONAL" OR "DIAGONAL"
Roof Slate sometimes 12"x12" with Undereave Slate 17"x8"

French Method (National Slate Assoc.)

3.5.4 Ridges

Documentary material mentions the use of stone and slate ridges with or without lead from Roman times:

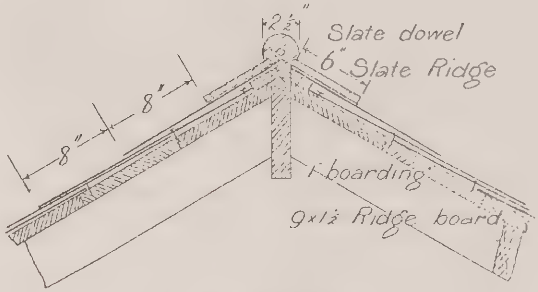
> The ridges of these slate roofs were originally formed by pieces of freestone chiselled into shape and bedded on with lime mortar. The lengths of the ridge-pieces were random: usually between 2 ft. and 4 ft. A surviving example can be seen on the right-hand roof at Hawkshead (1650). Later these gave place to purpose-made ridge tiles of blue Staffordshire clay in standard lengths (1650),... which was undoubtedly a change for the worse. If wrestler slates were used, ridge pieces were unnecessary... Wrestler slates... have slots carefully cut out of their sides, so that they interlock (hence the name 'wrestler') at the ridge. They can still occasionally be found in the Lake District: for instance at Grasmere, on the church... and on the interesting bee-wall in the garden of Dove Cottage. They are difficult to cut and therefore no longer used (Clifton-Taylor, pp. 171, 177).

Documents of later periods mention that slate was being used for building ridges:

> Slate Hips and Ridges are now much used in the place of lead. The slate ridges are holed and bedded in hair mortar, the holes filled with white lead and secured with copper screws and the adjoining pieces dowelled horizontally together with small slate dowels (Mitchell, p. 1).

A good description of ridges used in 1919 is provided by the International Library of Technology text: a metal saddle flashing, with the slate finished over it; a wooden ridge saddle with or without saddle flashing, to which the slates are butted and a wing flashing added; and the use of slate rolls and wings.

The National Slate Association, the Doney Slate Co., described a saddle ridge, a strip saddle ridge and a comb ridge, all formed into a final row of ridge. Slates were laid vertically or horizontally and butted or overlapped in different ways.



Slate Ridge (Mitchell)

Ridge and Closed Valley (National Slate Assoc.)

3.5.5 Hips

Several methods of forming slate hips are common. The following summaries come from the National Slate Association publication of 1926:

a. Saddle Hip
   The saddle hip can be formed by placing a lath strip along the edge of the roof hip on top of the sheathing. Roofing slates are then laid to stop at the edge of this lath strip.

   The hip slates are then laid on top of the lath strip. The slate width is the same as the exposure of the roof slates. Each hip slate is fastened with four nails driven into the lath strip. Elastic cement is used under the lower part of each slate to cover nail heads on the points between roofing slates and plaster lath and on the peak of the hip before laying the slates.

Metal Ridge on Dormer and Roof – United Church, Church St., Belleville, ON

On less expensive roofs the hip may be formed of narrower slates laid with butt joints not necessarily lined up with the courses of roofing slate. The latter hip is called the strip saddle hip.

b. Mitred Hip
The mitred hip can be formed by laying the roof and hip slates in one plane. The hip slates are the continuation of the roofing courses of slate with accurately cut edges to form tight joints. The hip joints are then filled with elastic cement. The nail holes are covered by the succeeding hip slate.

When the bottom edge of the hip slate is cut at an angle, it forms a fantail and thus the hip is known as the fantail hip.

c. Boston Hip
Boston hip is formed by weaving the hip slates in with the regular courses of the roofing slates. Elastic cement should be used on nail holes and under the lower part of each slate (National Slate Association, p. 18).

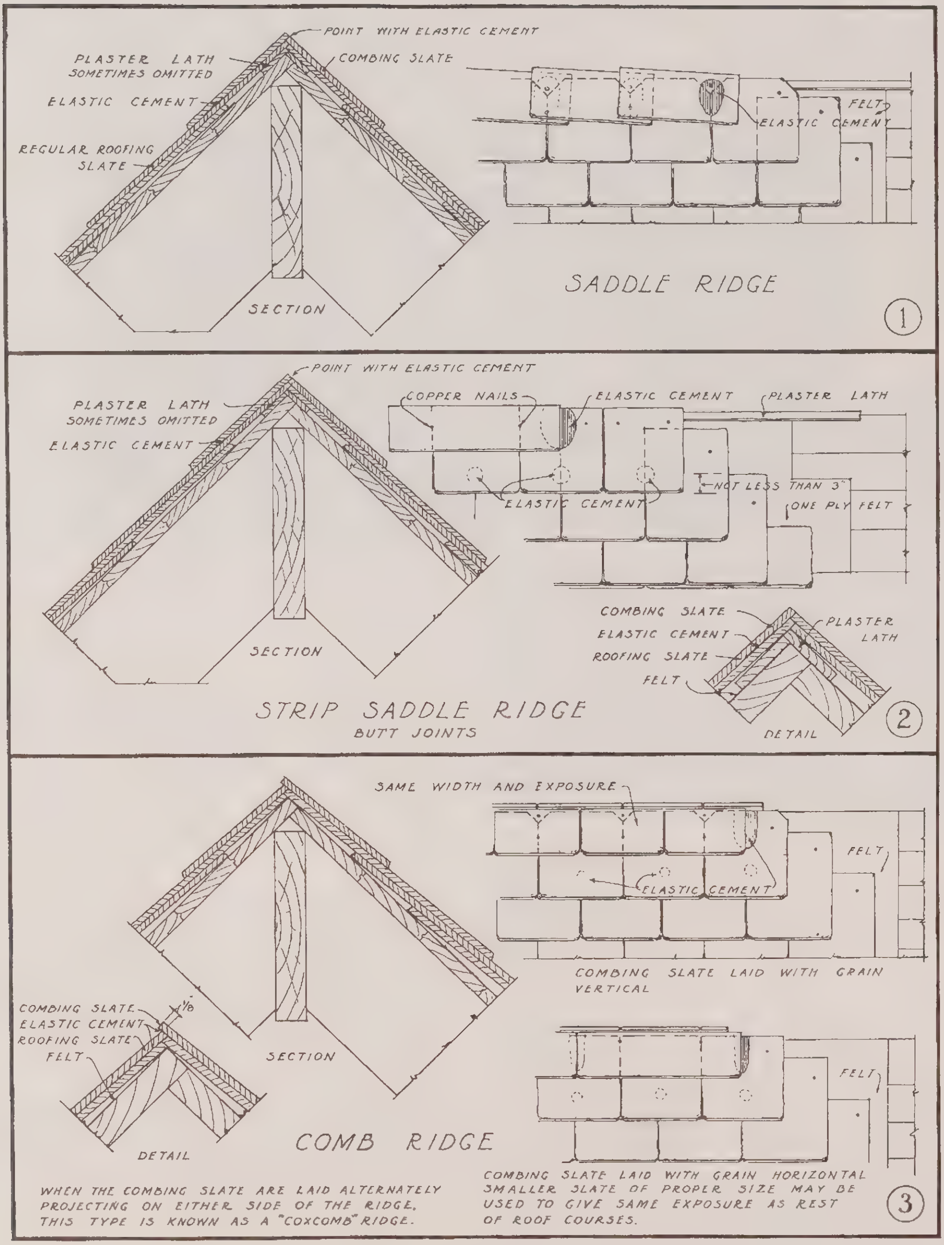
3.5.6 Valleys

The International Library of Technology recommended that valleys be constructed in the same manner as those described for shingle roofs (see Section 9.1).

There are two types of valleys – the open valley and the closed valley. Documents from the turn of the century described the methods:

> A closed valley is one in which the slates are mitered and flashed in each course and laid in cement. In such valleys no metal can be seen. Closed valleys should only be used for pitches above 45°. An open valley is one formed of sheets of copper or zinc 15 or 16 in. wide, over which the slates are laid (Kidder).

The National Slate Association gave a complete explanation of the two methods of forming valleys, the open valley and the closed valley.



Standard Details Slate Ridges (National Slate Assoc.)

Fantail Hip (National Slate Assoc.)

A Summary follows:

a. Open Valley:

The open valley is formed by laying strips of sheet metal in the valley angle and lapping the slate over it on either side, leaving a space in between as a channel to drain the water. This channel increases in width towards the bottom to allow for the increasing amount of water down the valley and to permit the ice to slide down freely.

The slating starts 2 in. from the valley centre at the top and should taper away from the centre at a rate of $^1/_2$ in. for every 8 linear feet.

Where the two roofs forming the valley have a considerable difference in slope or in size and cause a large variation in the volumes of water to be delivered into the valley, the metal should be made with a standing seam to break the force of the water from the steeper or longer slope and prevent its being driven up under the slate of the opposite side.

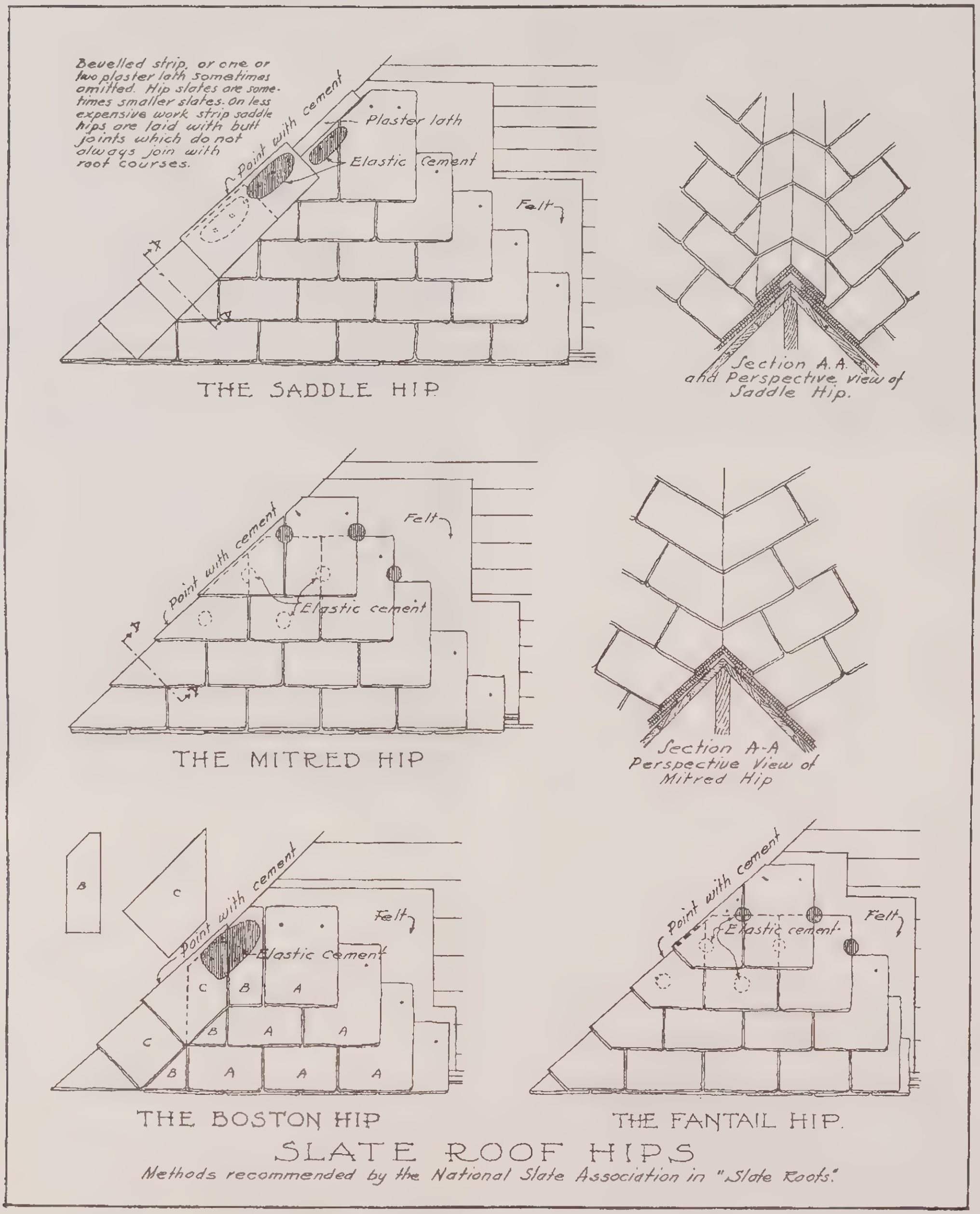
The flashing metal sheets should be tapered to accommodate the increasing width of the valley, by increasing the width of each sheet toward the bottom. The flashing should extend 4 in. - 8 in. under the slate and as far as possible without being punctured by nails.

Closed Valleys and Mitred Hips – St. Andrews Residence, Univ. of Saskatchewan, Saskatoon, SK (photo 1979)

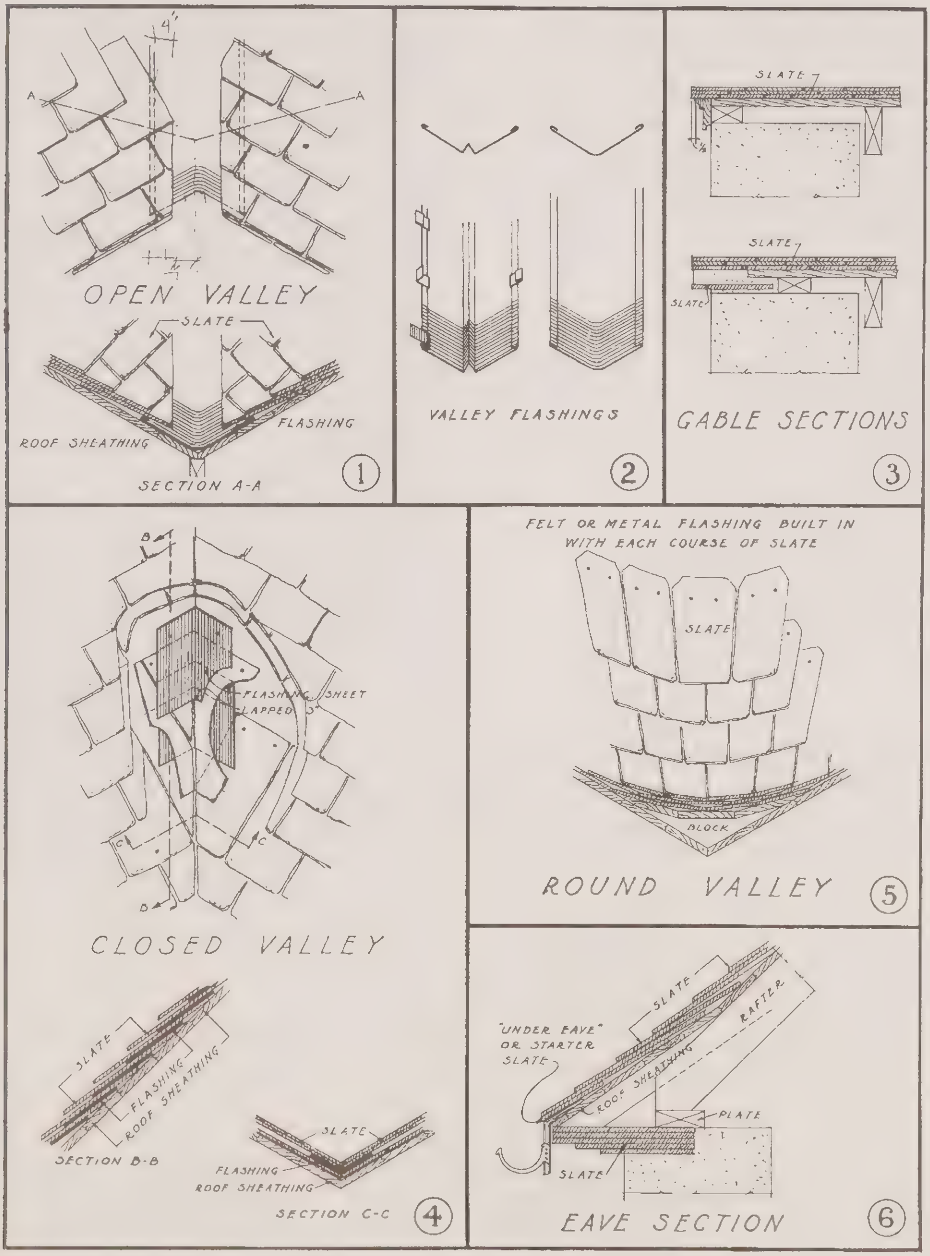
b. Closed Valley:

The closed valley is formed with the slate worked towards the centre of the valley to meet tightly the slate of the other side of the roof. Pieces of flashing metal are placed under each course of slate. The metal sheets should extend 2 in. above the top of the slate on which it rests so that it may be nailed along the upper edge of the roof sheathing without the nails penetrating the slate. Metal sheets should also lap the sheets below by 3 in. and be set back under the slate above so that they will not be visible.

A variation of using the metal sheets is to form a crimp corresponding to the centre line of the valley. This stiffens



Standard Details – Slate Hips (National Slate Assoc.)



Standard Details Slate Valleys, Eaves and Gables (National Slate Assoc.)

the sheets, forms a line for setting the slates and prevents water from passing from one slope to another.

A variation of forming a closed valley is by laying the sheets in long pieces along the valley centre line directly on the felt or paper which covers the sheathing. The sheets should lap 4 in. in the direction of the flow and should be nailed along the outer edge every 18 in. Slate is then laid on carefully to avoid driving nails though the sheets.

c. Round Valley:

The round valley, actually a variation of the closed valley, requires care and experience to achieve water-tightness and its distinctive pleasing appearance. The valley slates are at least 4 in. longer than the roof slates and should correspond to the roof courses. The sides of valley slates are trimmed to the radius of the valley and tops should be shouldered so that slates can lie flat. With proper trimming and fitting one can omit the use of flashing if desired. When flashing is used, especially where ice may form, it should be trimmed to the proper radius.

The radius for a round valley at the eaves should not be less than 26 in., which will then gradually diminish to zero at the ridge.

A variation of the round valley is the "canoe valley," used when roof conditions do not permit the proper radius at the eaves to form a round valley. The canoe valley has a radius of zero at both the eaves and the ridge. The radius increases gradually to the maximum halfway between the eaves and the ridge (Doney Slate Co., pp. 18-19).

3.5.7 Eaves and Gables

Slate roofs are laid commencing at the eaves: The doubling eaves course is laid with its regular edge up; the course above and all succeeding courses are laid with their regular edge down, so as to obtain a close joint to guide away the rain and wind (Mitchell).

The National Slate Association explained the method of starting slate at the eaves. The under-eave slates should start on a cant strip (tilting fillet) of suitable thickness, depending on the thickness of the slate. The first course is laid over this course enabling the second course of slate to be correctly laid. In the case of a cornice, the under-eave slates should project about 2 in. beyond the cant strip, sheathing or finishing member. The length of these slates is found by adding 3 in. to the exposure used on the regular slates. Thus, if 16 in. slates are used, the exposure is 6 $^1/_2$ in. and the size of the under-eave slate required is 9 $^1/_2$ in. Half slates are sometimes used or roofing slates of the proper width may be laid horizontally.

Although the slates of the under-eave course can be the same thickness as the starters (slates of the first course), usually they are half the thickness of the starters. For $^3/_4$ in. starters $^3/_8$ in. under-eave slates are used and for $^1/_2$ in. starters $^1/_4$ in. under-eave slates are used.

The first course of slate is laid over the under-eave course with the butts of both courses flush and the joints broken (Doney Slate Co.).

> When changing from a roof of flat slope to one of steeper slope as in the case of a Gambrel roof, the slate of the upper and flatter roof should project 2" to 2-$^1/_2$" beyond the steeper roof below. A cant strip should also be used upon which to start the slate of the roof of lesser slope the same as at the eaves.
>
> At the gables the slate should overhang the finishing member of the verge board not more than $^1/_2$". Where close-clipped gables are used or the constructon is such that the gable slates have ample nailing, this dimension may be increased, but the projection ought not to be too great for good appearance. Also there are many interesting ways to lay "Gable end" or "Barge" slates under regular courses along gable ends where shadow effect is desired. Ways and means of using and securing all gable end slates depends on type of construction (Doney Slate Co., p. 23).

3.5.8 Flashing

Flashing should be used on the intersection of roofs with the same slope or different slopes. It is also necessary at the intersection of all surfaces projecting through the roof or where the roof abuts.

Flashings used over or under the roof covering and turned up on the vertical surface are known as "base flashings." Metal built or laid between the courses into the vertical surface and bent down over the base flashing is termed "cap flashing" or "counter flashing."

Eaves Slating and Flashing – St. Andrews Residence, Univ. of Saskatchewan, Saskatoon, SK (1979)

The International Library of Technology noted:

> Valleys may be constructed in the same manner as those described for shingle roofs, as may also the flashings around the chimneys, skylights, bulkheads, ventilators, etc. (International Library of Technology, p. 89).

The same publication gave additional information on slate roof flashing where it finished against or abutted a vertical wall:

> Where a slate roof finishes against a parapet, gable or other wall of brick or stone, there should be provided both flashings and counterflashings, the flashings to be cut in short lengths, 2 inches longer than the unexposed part of the slate and to be laid as each course of slate is put on. This flashing should have a lap on the roof equal to the width of one-half a slate and should turn up against the wall at least 4 or 5 inches. The flashing against the wall should not be nailed, for if the roof were to settle, the flashing would lift the slates or break them. This flashing is sometimes called a "soaker." The counterflashing which covers the soaker flashing, is either let into a reglet cut 1 inch deep in the stone or stepped into the joints. This stepped counterflashing is secured at the top by wall hooks and the joints are well pointed with plastic cement (International Textbook Company (*Roofing)*, p. 89).

More detailed descriptions of slate roof flashing can be found in the 1926 publication of the National Slate Association.

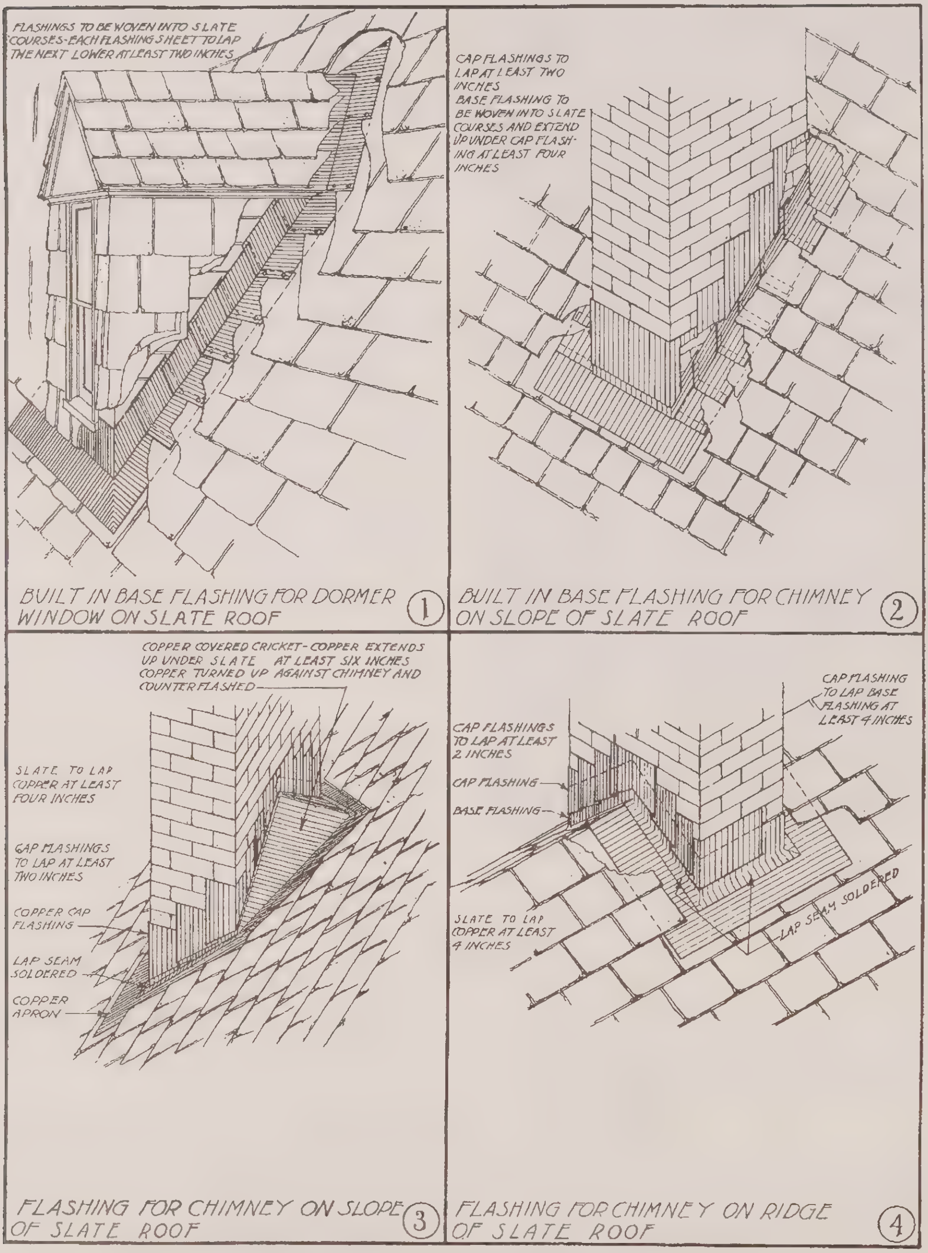
3.5.9 Nailing or Fixing by Metal Hooks

Nailing is an important, sensitive part of slating roofs. Nails should not be driven so tightly that they break through the nail holes. They are then of little value for holding slate in place. Nails also should not be insufficiently driven. This causes the nail head to be forced through the upper slate by pressure from above.

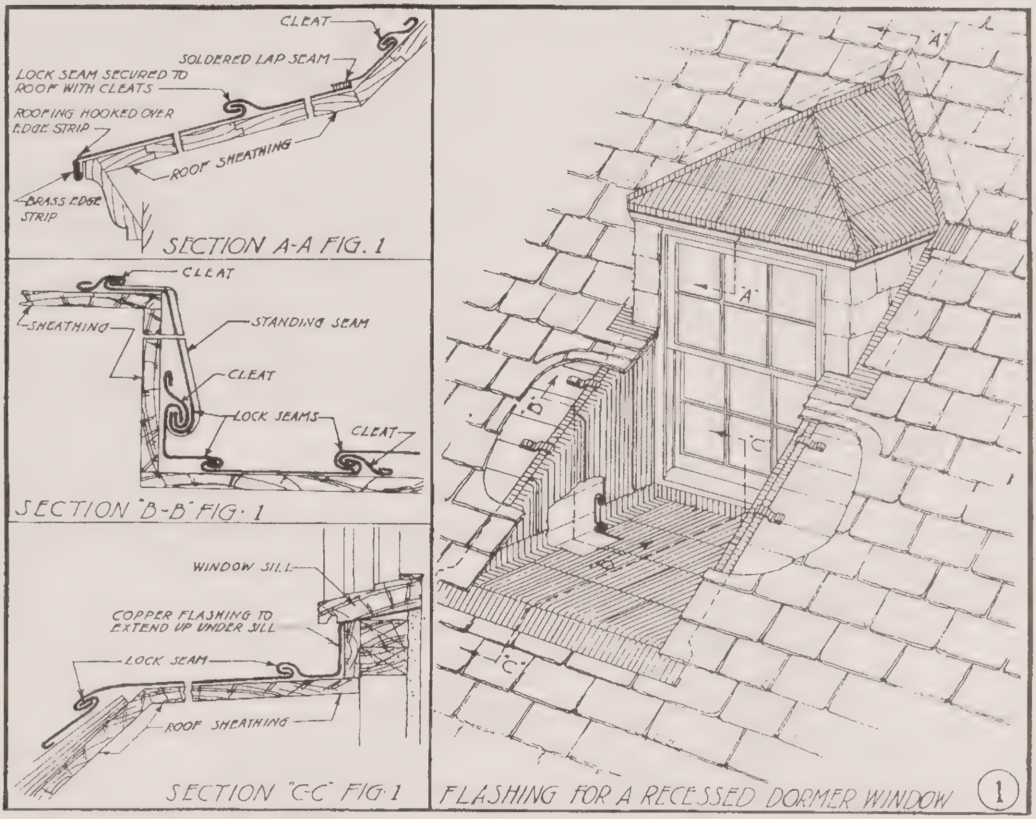
Two methods of nailing are mentioned in the International Library of Technology text on roofing. They are head-nailing and shoulder-nailing.

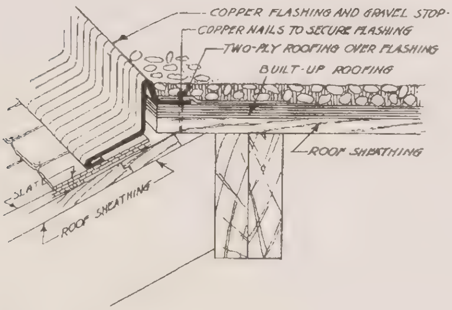
> In head-nailing, which is the usual method employed the nail holes are punched about 2 inches from the top and the tails of the next two courses lap over the nail holes. Should the first-covering slate become broken, the nails are thus still protected from the weather by the lap of the second-covering slate. The objection to this method is the leverage exerted by the wind. In shoulder nailing, holes are punched at a distance from the tail of the slate equal to a little more than the gauge plus the lap (pp. 82-83).

In 1926 the National Slate Association recommended that slates $^3/_4$ in. or more in thickness and more than 20 in. in length should have four holes. Holes are punched about one-third the length of the slate from the upper part and about $1^3/_4$ in. from the edge. When two more holes are added, they are located about 2 in. above the regular holes (National Slate Association, p. 13).

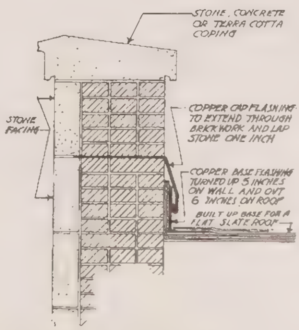


Standard Details Flashing (National Slate Assoc.)





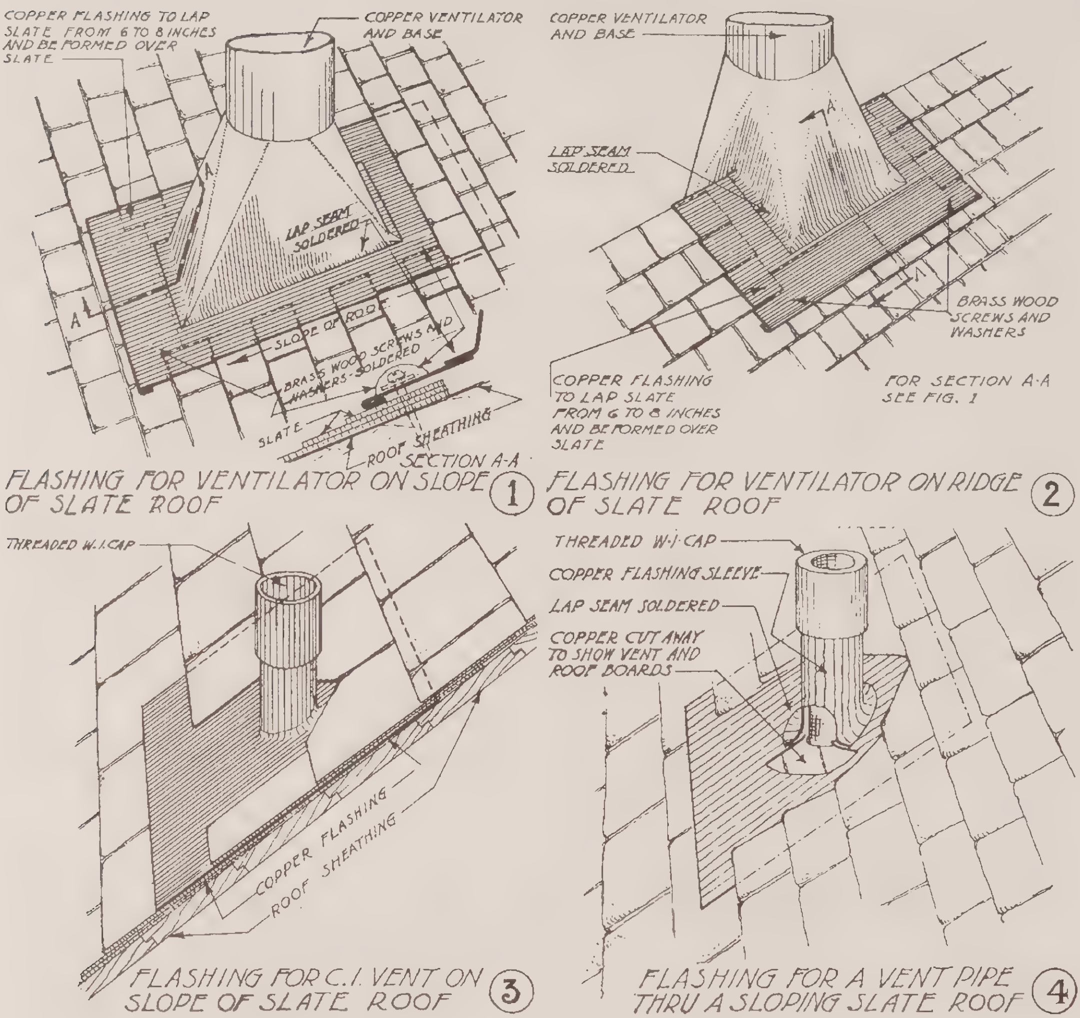
FLASHING FOR EDGE OF COMPOSITION DECK ROOF ABOVE A SLOPING SLATE ROOF



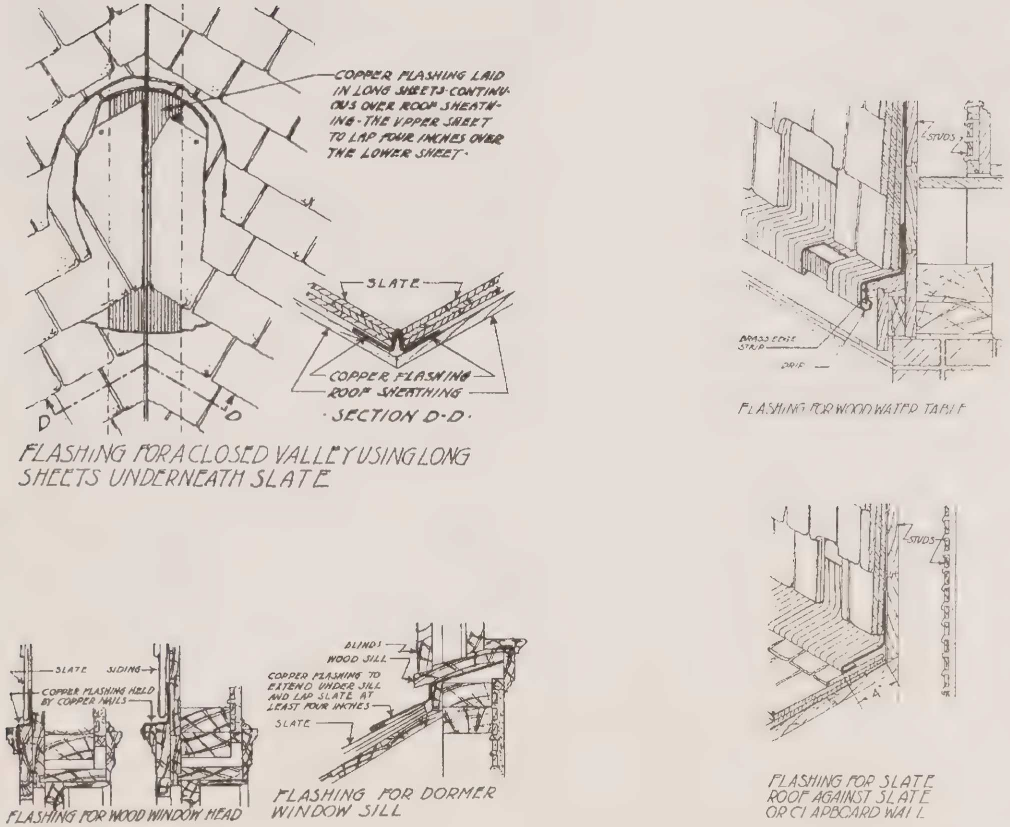
FLASHING FOR A BRICK PARAPET WALL FACED WITH STONE

When a parapet wall is flashed on the top and back with metal, the flashing should be carried over and down to within one inch of bottom of cap flashing formed as here shown, so that most of the water is deflected out onto the slate.

Flashings (National Slate Assoc.)

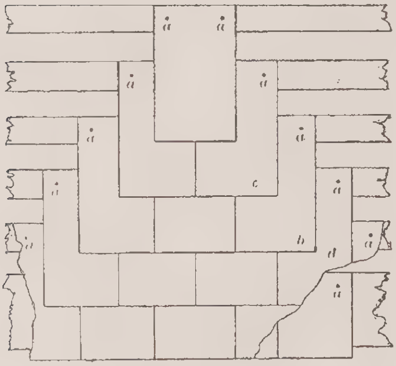


Flashings (National Slate Assoc.)

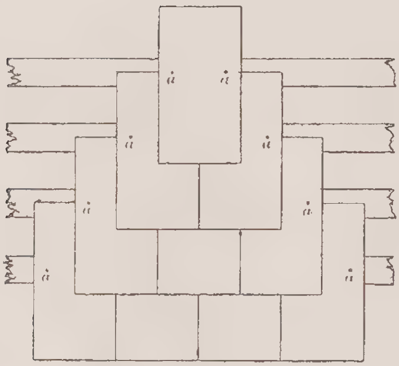


Flashings (National Slate Assoc.)

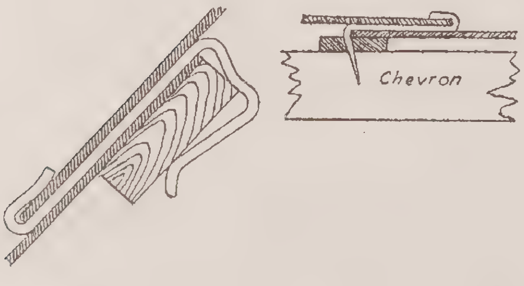
Fixing slates by hooks was not mentioned in North American sources. However it was amply referred to in French documents from the turn of the century and as recently as 1959. Arnaud in 1925 mentioned that "crotchet" hooks for fixing slates are made of copper galvanized iron. The hooks pass between two adjacent slates and the turned heads of the hooks prevent slates from sliding down or being blown away – a major cause of the destruction of slate roofs. The hooks are made in many different forms and models for roofs of wood battens or iron lattice (Arnaud, p. 266).



Head Nailing



Shoulder Nailing (International Textbook Co.)



Slate fixed by hooks (Mouchel)

Alphonse Mouchel in 1959 called slates roofs fixed by hooks, "couverture sans liaisons." The name was given because the hooks lie between two adjacent slates, preventing contact between them. Mouchel described two kinds of hooks, the first hooks around the battens, the second nailed through the batten.

3.6 PATTERNS OF SLATE ROOFS

A mention of early patterns and slate shapes was noted in *The Pattern of English Building*. The Romans cut their slate into a variety of shapes, including elongated hexagons and rough ovals. The French found wedge-shaped slates convenient for the circular turrets and tapering of conical roofs abundant in their architecture. They also used saw-tooth and scale-like patterns. The English used roofing slates curved at one end to create a greatly magnified fish-scale pattern (Clifton-Taylor, p. 172).

The hexagonal and oval shaped slates continued to be used until the middle ages. In later times the tails were cut square and the heads left a rough oval (Innocent, pp. 174-77).

In the early 20th century, the Old English method of laying slates become popular. The slates for this kind of roof were made with rough cut edges in all thicknesses, widths and combinations of colour shades and laid in graduated courses. They were selected in proportions to produce the best possible harmony when laid (Kidder, p. 1498).

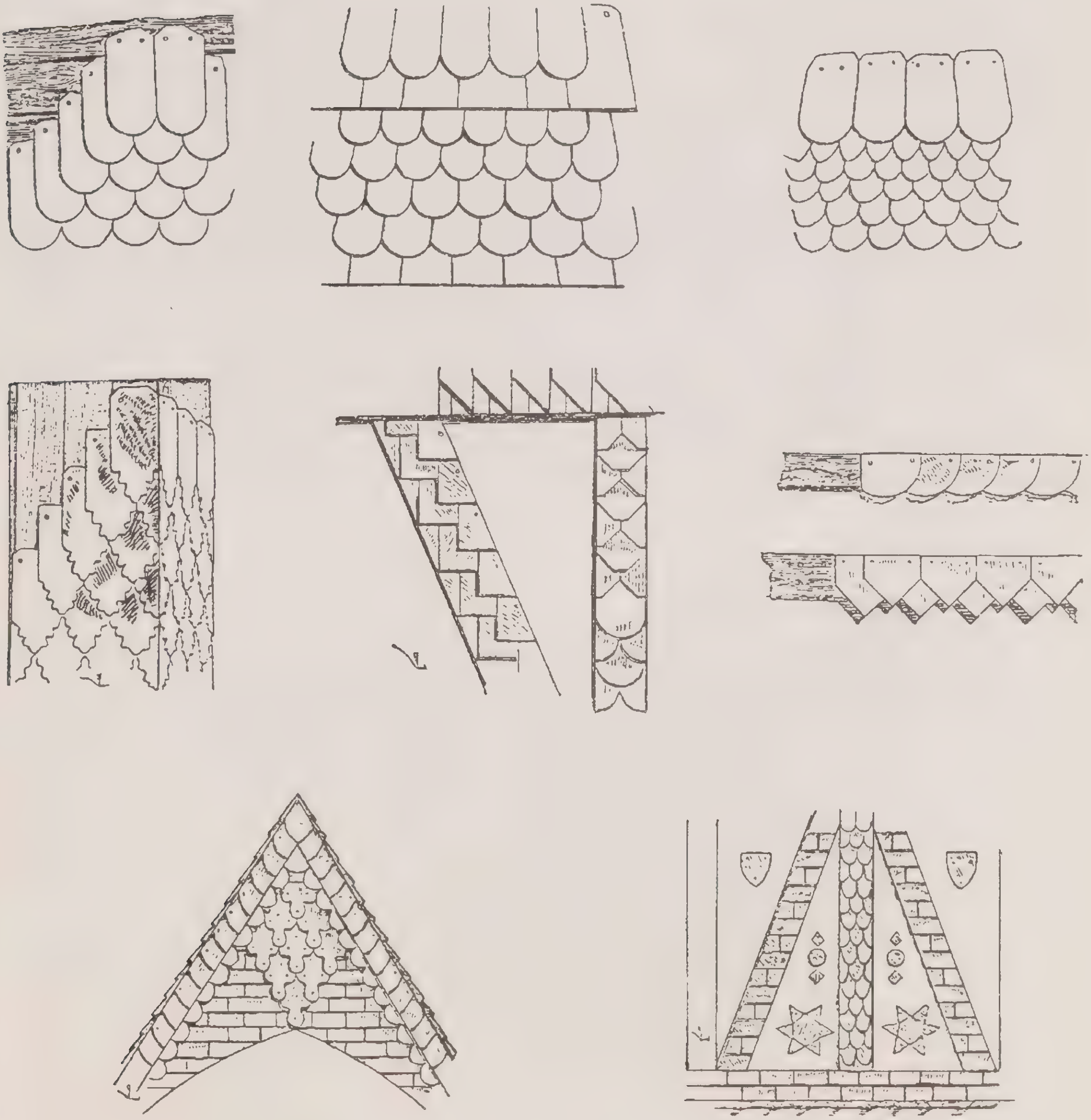
The most elaborate patterns are mentioned in French publications. By far the most extensive number of patterns was found in the *Dictionnaire raisonné de l'architecture française* published in 1875 by Viollet Le-Duc. He discussed the different patterns popular in each area, the slate colours used and sources of these slates (Viollet Le-Duc, pp. 453-59).

3.7 REPAIRS TO SLATE ROOFS

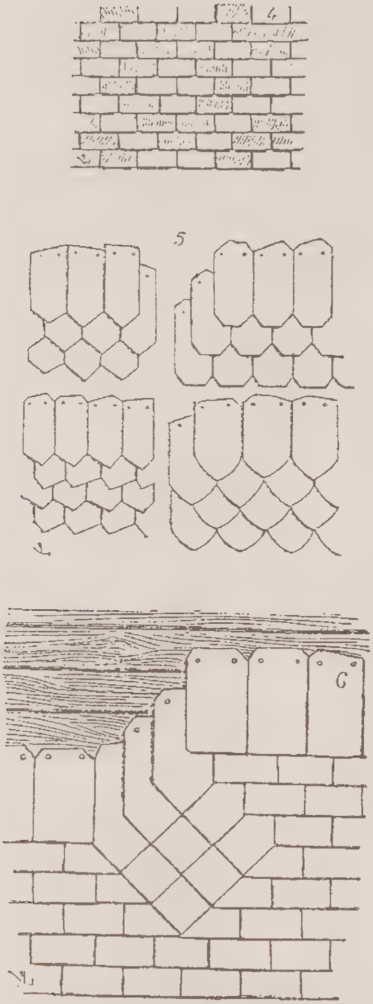
3.7.1 Reroofing with Slate

Removing old slate from the roof surface allows proper examination of the roof construction for repairs of sheathing, felt and insulation.

A reasonably smooth undersurface is essential to the proper laying of a slate roof. If lathing is not removed, new boards should be used to fill the space between the old lath. Both should be the same thickness to provide a reasonably smooth



Patterns of Slate Roofs (Mouchel)



Patterns of Slate Roofs (Mouchel)

surface. It is important to go over the roof, removing and driving in projecting nails and also to cut down warped or raised edges of sheathing and lath. After sweeping the roof free of chips and loose nails, the felt should be laid.

Reroofing with slate can be done on roofs covered with other materials too, such as shingle roofs, without removing the old roof covering. This has given satisfactory results for years especially in conserving heat. However, for high grade work the old roof covering should be removed for proper inspection of roofing members, especially if inspection from the underside is impossible. One slater recommended slates of 18 in. or longer as best for covering shingle roofs, so that the slate spans at least two courses of the wood shingles.

Using four nail holes has been recommended: if good nailing could not be obtained with one pair, the other pair could be used.

Another slater, a specialist in over-shingle slating, states that slates 12 in. or 14 in. long fit the contours better and are less liable to break (Doney Slate Co., p. 67).

3.7.2 Additions and Alterations to Slate Roofs

Slates from some quarries weather, while slates from other quarries are permanent or unfading. Matching slates that are unfading require using unfading slate of the same shade or slate which will weather to the desired shades. Securing slate from the original quarry reduces matching and colour problems. Unfortunately quarry records are poor.

An experienced roofer can usually identify slate according to veins. However, samples can be sent to the National Slate Association for identification:

> The best... procedure is to remove small adjoining sections and relay, mixing some new slate with the old. This will prevent a clear line of demarcation where the new work adjoins the old and the completed roof will ...present a satisfactory appearance.
>
> In minor alterations such as adding or removing a dormer, the old slate which is removed can be used again. In dormers and other projections, the lights and shadows will differ from those on an expanse of roof, making it easier to add new slate which will be unnoticed. For example, new slates could best be used on cheeks of a new dormer using old slates on other parts.

Tower roof being mobilized

Tower roof reinstalled in place after reroofing

Reroofing the Tower Top of a Structure. The tower roof was moved to a workshop, re-covered with slate and moved back to be installed on the tower.

Some roofers buy up a number of old roofs from buildings which are being torn down and thus obtain old weathered slate in their yards which can be readily matched with the slate on the roof when minor alterations are made (Doney Slate Co., p. 69).

3.7.3 Replacing Single Slates

For repairing defective roofs, lead and copper tacks are mentioned in *Building Construction and Drawing*:

> The broken slates are removed, the nails being cut or drawn by a tool called a ripper, the tack is then hooked over the head of the slate below, the new slate is inserted and the lead clip turned up over the tail. Two tacks should be used to each slate.
>
> These lead or copper hooks are usually about $^1/_2$ in. wide, the distance between the hooked ends being equal to the length of the slate minus a gauge (Mitchell).

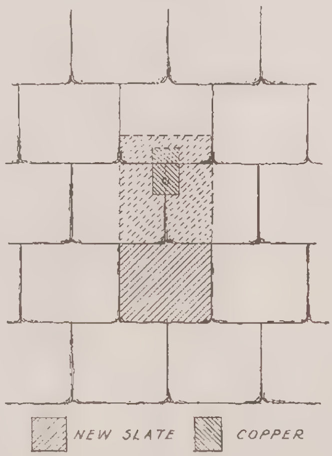
Later in 1926 the National Slate Association recommended another method:

> ... remove the broken slate, cut the nails with a ripper and remove any remaining small pieces of slate. Insert new slate and nail this slate through the vertical joint of the slates in the overlying course approximately 5 inches from the head of the slate, or 2 inches below the tail of the second course of the slate above; over this nail insert a piece of copper approximately 3 inches in width by 8 inches in length. The piece of copper should be inserted under the course above, lengthwise, so that it will extend a couple of inches under the succeeding course, thus insuring a proper lap and protection throughout the exposed joint in which the nail is driven. This small piece of metal should be first bent slightly concave or convex which will insure its remaining tightly in place (Doney Slate Co., p. 69).

In *The Care of Old Buildings Today*, Insall warned slaters against using lead tabs (previously mentioned as "tacks"). They can gradually open and release and the slates and are liable to damage when brushing the roof to clear snow. He recommended copper tabs:

> Copper tabs are stronger; but the best device of all is to slot the slates at their fixing holes, where they will later be protected by the course above and to hook in stout copper tabs, tucked through the slots and laid flat on the underside. The slate may then be slid up into position, with the tabs in place, to be turned down over the battens from inside. This is only practicable when there is reasonable access to the roof-space. The common but bad practice of drilling and screwing tiles into place with brass screws and washers, covered with mastic, is a fundamental error and can never make a good job (Insall, p. 107).

Repair of valleys by amateurs give bad results in appearance and function. United Church, Church St., Belleville, ON, 1980.



Proper Method of Inserting New Slate (National Slate Assoc.)

4.0 BIBLIOGRAPHY

Association for Preservation Technology, Bulletin of the. 1970. "Early Roofing Materials," Vol. 2, Nos. 1-2, pp. 24-51.

Architectural Construction. 1958. New York and London.

Arnaud, M.E. 1925. *Cour D'Architecture et de Constructions Civiles.* Paris.

Bixby, M.G. & Co. 1886. *Industries of Canada, Historical and Commercial Sketches of Toronto and Environs.* M.G. Bixby & Co., Publishers, Toronto.

Blondel. 1777. *Toit Revêtement.*

Brunskill, R.W. 1978. *Vernacular Architecture.* Faber and Faber, London and Boston.

Buggey, S. 1972. *Restoration of a Complex of 19th Century Offices and Warehouses.* Ottawa.

Chabat, Pierre. 1875. *Ardoise: Dictionnaire des terms employés dans la construction.* Vol. 3. Paris.

Chambers Encyclopedia. ca. 1869. "Slate."

Clifton-Taylor, Alex. 1965. *The Pattern of English Building.* Faber and Faber Ltd., London.

Cochrane, Wm., Rev. 1893. *The Canadian Album: Men of Canada.* Vol. 2. Bradley, Garretson & Co., Brantford.

Compressed Air. 1972. "Underground Slate Quarry," BPA Periodical (March). NJ.

Davey, N. 1961. *A History of Building Materials.* London.

Doney Slate Company. 1953. *Slate Roofs.* For National Slate Association, 3rd edition. Pen Argyle, PA. Quoted material and illustrations reprinted by permission: Vermont Structural Slate Co., Inc., Fairhaven, VT.

Eckel, Edwin C. 1912. *Building Stones and Clays.* John Wiley & Sons, New York and Chapman & Hall Limited, London.

Fayard. 1962. *Ardoise.* Cours Superieur de L'Historie, la Construction, Conservation et Restauration des Monuments Anciens. Paris.

__________. 1962. *Couverture.* Cours Superieur de L'Histoire, la Construction, Conservation et Restauration des Monuments Anciens. Paris.

Gwilt J. 1867. *An Encyclopedia of Architecture.* London.

Hauf, Harold D., and Joseph N. Beaz. 1970. *The Architectural Graphic Standards.* John Wiley and Sons Inc., New York, London, Sydney, and Toronto.

Hodgson, Fred T. 1906. *Hodgson's Estimator and Contractor's Guide for Pricing Builder's Work.* Frederick J. Drake & Co, Publishers, Chicago.

Innocent, C.F. 1916. *The Development of English Building Construction.* CVP. Reprinted & raised 1971 by David and Charles, Devon, UK.

Insall, Donald W. 1972. *The Care of Old Buildings Today.* The Architectural Press, London.

International Correspondence Schools. 1899. *The Building Trades Pocketbook.* 1st edition. The Colliery Engineer Co., Scranton, PA.

International Library of Technology. 1909. *Roofing.* International Textbook Co., Scranton , PA.

Kidder, Frank Eugene. 1915. *Architects' and Builders' Pocketbook.* 16th edition. John Wiley and Sons, New York.

L'ardoise. Bimonthly periodical on slate. Paris.

Lindsay, Jean. 1974. *A History of the North Wales Slate Industry.* David & Charles, North Pomfret, VT, and West Vancouver, BC. Illustrations reprinted by permission: Gwasanaeth Archifan Gwynedd Archives, pp. 33, 86, 103, 157, 209.

McKee, H.J. 1971. *Early American Masonry Materials in Walls, Floors and Ceilings.* Syracuse, NY.

Mitchell, Charles F. 1911. *Building Construction and Drawing.* 8th edition. London.

Mouchel, A. 1959. *La Couverture*. Paris.

Needham, W., and B. Mussey. 1880. *Grandfather's Book of Country Things*. U.S.A.

Nolan, T. Editor in Chief. 1914. *Kidder's Architects and Builder's Pocket Book*. 16th edition. Philadelphia, PA.

Ramsey, Charles G., and Harold R. Sleeper. 1956. *The Architectural Graphic Standards*. John Wiley & Sons Inc., New York and London. Reprinted by permission of John Wiley & Sons, Inc., New York.

Ritchie, T. 1967. *Canada Builds 1867 - 1967*. University of Toronto Press, Toronto.

Structural Slate Company, The. n.d. *Repairing Slate Roofs*. Pen Argyle, PA.

Vermont Structural Slate Co., Inc. 1925. *Slate Roofs*. For National Slate Association, Fair Haven, VT.

Viollet-Le-Duc, E. 1875. *Dictionnaire raisonné de l'architecture française*. Paris.

Walker, Frank R. 1927. *The Building Estimator's Reference Book*. Frank R. Walker Company, Chicago.

Young, W. 1881. *Spons' Architects' and Builders' Pocket-book*. 8th edition. E. & F. N. Spon, London and New York.

Slate Companies

Buckingham Virginia Slate Corporation
1103 East Main Street
Richmond, VA.

Broughton Moor
Green Slate Quarries Ltd.
Coniston the Lake District Lancs.
c/o Canadian Agents
New England Slate
St. Catharines, ON.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

10
PERIOD GLAZING AND GLASS

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: B. HUMPHREYS

CONTENTS

1.0 INTRODUCTION

Glass is made by heating a mixture of soda, lime and sand to a high temperature until it fuses into a vitreous mass. It is an ancient process dating back some 5000 years to the Egyptian and Mesopotamian empires.

Initially glass was used to make solid objects and later, around 1500 B.C., to manufacture vessels. The Phoenicians developed the blowpipe in 300 B.C. and glass-blowing followed. The Romans developed a method of rolling glass into sheets; the end product had a pale green colour. The first relatively clear glass was developed by the Venetians ca. 1000 A.D. Although various improvements were made in Europe in the late 17th and 18th centuries in the method of producing plate glass, it remained a handcrafted process until late in the 19th century when mechanization began in England and in the early 20th century in the United States.

Little progress was noted in glass production methods until 1959 when float glass was introduced in England. It has all but superseded previously established methods of producing sheet glass.

1.1 GLASS IN CANADA

Prior to the establishment of the first window glass factory in Canada (ca. 1845), all window glass was imported, mainly from England. Early glass was available in small panes only, the customary sizes being 175 mm x 225 mm (7 in. x 9 in.) and 200 mm x 250 mm (8 in. x 10 in.); larger sizes were available by mid-19th century. In 1846 the Canada Glass Works in St. Jean was offering "all sizes and qualities," and two years later the Ottawa Glass Works advertised "5000 boxes of all sizes from 150 mm x 200 mm (6 in. x 8 in.) to 760 mm x 1067 mm (30 in. x 42 in.) ... of very superior quality. 100 boxes Double Thick from 200 mm x 400 mm (8 in. x 16 in.) to 760 mm x 1016 mm (30 in. x 40 in.) equal to the Best German plate" (Pacey).

Glass sheets were produced by the handblown cylinder method only and were graded numerically (firsts to fourths) for quality – based on clarity, smoothness and colour. Thickness was determined by the number of grams per square centimetre (ounces per square foot) with 425g, 595g, 907g, 1020g and 1190g (15, 21, 32, 36 and 42 ounces) being the standards and 425g and 595g (15 and 21 ounces) the most popular. Regardless of pane size or weight, the glass was shipped by a standard "box" which contained 9.29 m^2 (100 square feet) of glass or a "half-box" containing 4.6 m^2 (50 square feet). As can be imagined, there was considerable breakage in transit, particularly in shipments to rural areas.

Glazing was done on site. The glass was secured against the rabbetted window sash with putty (linseed oil and pigment). Sash planes were found among the early carpenter's tools and the putty was probably imported. It is known to have been issued along with small window panes to the Loyalist settlers. It is likely that the use of glazier's points – small triangular metal pieces driven into the sash – were of much later origin.

1.2 GLASS HOUSES IN CANADA

There were no glassworks or factories in Canada prior to the middle of the 19th century (as noted above). However the last half of the century saw a great flurry of activity in the glass manufacturing business when nearly twenty glasshouses began producing glassware of all kinds. Of these, the following were producing window glass: Canada Glass Works, Dorchester, Canada East (St. Jean, PQ, 1845 to ca. 1854). It was the first known window glass factory operating in Canada. The Ottawa Glass Works at Vaudreuil, PQ (1845 to 1857); the New Brunswick Crystal Glass Company, Courtenay Bay, NB (1874 to 1878); and the Napanee Glass Works, Napanee, ON (1881 to 1883).

However, due to economic conditions of the time and the effect of fluctuating trade agreements with England and the United States, the failure rate of glassworks was high. By 1880 only three were still operating and none of them were producing sheet glass. After the failure of the Napanee Glass Works in 1883, "Canada would remain totally dependent on foreign producers for her window glass needs for the next thirty years" (Pacey).

The 20th century saw the establishment of a mechanized glassworks in Cayuga, ON, a subsidiary of the American Window Glass Machine Co. (later taken over by Pilkington Bros. in Thorold, ON). Glass was manufactured there by the drawn cylinder process. In 1920 the Canadian Libby-Owens Sheet Glass Co., built in Hamilton, ON, introduced the drawn flat glass process. This process was also used by the Industrial Sheet Glass Co., established in 1941 in Ville St. Laurent, PQ, and bought out by Canadian Pittsburgh Plate Glass Co. in 1949. By 1970 both the Canadian Pittsburgh Plate Glass Co. and Pilkington Glass Industries had constructed plants, the former at Owen Sound, ON, and the latter at Scarborough, ON. Both used the float glass method.

2.0 TYPES OF SHEET GLASS

Unlike some building components (such as plaster) which are denoted by their composition, types of sheet glass are named by their method of manufacture: cylinder, crown, cast, drawn and float.

2.1 CYLINDER GLASS

The blower collects a ball of molten glass on the end of a long blowpipe and blows it into a sphere, at the same time swinging it gently in a pit or trench, allowing the weight of the glass to pull the sphere into a cylinder. This cylindrical shape is removed from the pipe, cut open and flattened by beating onto a stone or iron surface. Early sheet glass produced this way tended to have a relatively rough surface and was limited in size to 900 mm x 1200 mm (3 ft. x 4 ft.). Subsequent improvements and increased skill led to the production of much larger sheets with flat, polished surfaces. This method and that of crown glass, were the customary ways of producing sheet glass during the early 18th century.

Mechanization of cylinder glass production developed early in the 19th century in the United States. Instead of being hand blown, the cylinder of glass was drawn, by machine, from a tank of molten glass. The cylinder, which could be as much as 12 m (40 ft.) long, was cut with an electrically heated wire, then heated, flattened and cut to size.

2.2 CROWN GLASS

The blower blew a sphere of molten glass into which an assistant forced an iron rod opposite the blowpipe. The sphere was snapped off the blowpipe and the glassblower spun the rod quickly enough to flatten it into a circle of thin glass up to 1200 mm (4 ft.) in diameter, which hardened without any surface contact. This produced a smooth surface and a clear glass, but its circular shape and the crown in the centre restricted the number of panes that could economically be cut from it.

2.3 CAST GLASS

This process was developed in France in the late 17th century in an effort to produce large sheets of glass. Molten glass was

Interior of crown-glass house showing various stages in making crown (McGrath and Frost, 1937)

poured onto a casting table (originally copper, later iron) and rolled before it set. The surface was then ground, polished and cut to size. This method, introduced into England in the late 18th century, was subsequently improved there with the introduction of the rolled plate process. In this method the molten glass was poured onto an inclined plate and passed between rollers, before being ground and polished. It proved to be a cheaper, and consequently popular, method in England, but does not appear to have been used in North America.

2.4 DRAWN GLASS

This was a mechanically produced sheet glass which involved the drawing of a continuous sheet or ribbon of glass on a "bait" from a tank. The ribbon was passed between a series of rollers which regulated the thickness and imprinted a pattern or texture if required. Glass produced by this method required no further polishing. Modifications of this method were commonly used in Canada and the United States until the introduction of float glass in 1959.

2.5 FLOAT GLASS

This is a simplified process whereby molten glass is fed in a continuous horizontal ribbon onto a bed of molten tin, removed on rollers, annealed and cut to size. The resulting glass is flat with a smooth surface which requires no polishing. Due to the relative simplicity of this method and the quality of the product, it soon superseded other methods in many of the major factories and practically eliminated the production of clear polished plate glass.

2.6 PLATE GLASS

This glass differs from sheet glass (float glass) only in its surface treatment. To achieve a bright, clear finish, the glass has to be ground and polished, whereas the clear surface of sheet glass is imparted by the heat of the molten glass in the tank from which it is drawn.

Plate glass, originally produced by the "cast" method – molten glass poured onto iron tables – was later produced by feeding a ribbon of glass onto rollers which cooled and flattened it to the required thickness. It was then annealed, cut to size, ground and polished. As noted, this system has now been superseded by the much simpler float method.

By courtesy of the British Museum

Method of making plate glass, developed by Louis Lucas de Nehou in France between 1675-91. The engraving shows the furnace and casting table with, in the background, a workman breaking frit for the post. (McGrath and Frost, 1937)

2.7 STAINED GLASS

The production of stained glass is an art which can be dated back to Medieval times. It was used predominantly in churches, partly for decorative purposes and partly to illustrate Christian beliefs for the many pilgrims of the time. It has continued to be associated with churches, but also became popular for secular buildings in the late 19th century.

In Canada the first stained glass was produced in 1856 by the interior decorating firm of Robert McCausland in Toronto, ON. The demand for decorative windows for domestic architecture

as well as for churches increased towards the end of the century. Large coloured and painted windows, often located at the stair landing, became a dominating feature of large houses built between 1890 and 1920. Smaller accent windows were also popular. A type of picture window with a single large clear pane surmounted by a narrow coloured and patterned window was common in the 1920s and 1930s for less grand houses.

A stained glass window was made by first preparing a drawing or pattern of the design indicating the lines of the lead jointing. Glass of selected colours was then cut to the required size and any additional painting added, usually in brown or black. The pieces were fired and then set in H-shaped "cames" of lead. When all pieces had been set, the joints were secured by soldering. While design styles have changed over the years, there has been little change in the method of manufacture. The production of stained glass windows is still very much a handcrafted process.

2.8 OTHER TYPES

Twentieth-century ingenuity has developed several specialized types of glass: safety glasses which include tempered glass that has been heat treated and is highly resistant to breakage; laminated glass made with a layer of plastic between two sheets of thin glass; wired glass which has a layer of wire mesh embedded in it; heat absorbing and glare reducing glasses produced by variations in the chemical composition; and reflective glasses made by tinting or coating float glass on one or both sides or by lamination (which protects the metallic surface).

Glass as an exterior finish (now popular in its mirror reflective form), was used quite extensively in the 1930s and 1940s in Canada and in the United States. Manufactured under the trade names *Vitrolite* or *Carrara*, it was an opaque, lime-based glass, very smooth on one side, lightly textured on the other. Developed in the United States in the early 20th century, it was originally intended as a substitute for marble and used for interior dados, table tops and fittings such as toilet stalls. This glass was later produced in a variety of colours with a very smooth and shiny surface and used as an exterior surfacing. It was generally seen on storefronts or commercial buildings where it was applied with large daubs of mastic in squares somewhat reminiscent of oversize ceramic tile without the mortar lines.

3.0 BIBLIOGRAPHY

Derry, T. K., and T. I. Williams. 1960. *A Short History of Technology*. Oxford University Press, Oxford.

McGrath, R., and A.C. Frost. 1937. *Glass in Architecture and Decoration*. The Architectural Press, London. Illustrations reprinted with permission: British Library, Great Russell St., London.

Pacey, Anthony. 1981. "A History of Window Glass Manufacture in Canada," *Bulletin of the Association for Preservation Technology,* Vol. 13, No. 3, pp. 36-43. Ottawa.

Pepall, Rosalind. 1981. "Stained Glass Windows in Montreal at the Turn of the Century," *Bulletin of the Association for Preservation Technology,* Vol. 13, No. 3, p. 54. Ottawa.

Rempel , John I. 1980. *Building with Wood*. Revised edition. University of Toronto Press, Toronto.

Shopsin, William. 1986. *Restoring Old Buildings for Contemporary Use*. Whitney Library of Design, New York.

Watson, Don A. 1978. *Construction Materials and Processes*. 2nd edition. McGraw Hill Inc., New York.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

11

PERIOD PLASTERING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: B. HUMPHREYS

CONTENTS

1.0 INTRODUCTION

Plaster is one of the oldest building materials and one of the most versatile. It was widely used by the Egyptians and the Romans as a surfacing material. Revived in 15th-century Europe, it served admirably for the creation of the elaborate decorative detail of the Baroque and Rococo styles of the time. In 18th-century England its use was popularized by the architect John Nash. He used it to surface brick structures to give them the appearance of stone or to provide the smooth, plain surfaces which were an integral part of the Regency architectural style. It was used also by the Adam Brothers to cast the delicate ornamental detail that was a distinguishing feature of their architecture.

Changes in construction in the 19th and 20th centuries have led not only to the continuing use of plaster as a surfacing material, but also to an extensive development of its properties for fireproofing structural members, acoustical treatment and insulation.

Despite its proven versatility, however, there has been a tendency to regard plaster with a certain amount of scorn as being a cheap and often lifeless substitute for stone or wood carving. However, since the architecture of today emphasizes honesty in the use of materials and eschews the use of highly decorative detail, flat, plain surfaces are still required. Plaster continues to be the popular means to provide them despite the many alternatives that have become available over the years.

1.1 PLASTER IN CANADA

In Canada the making and use of plaster was introduced by the early settlers. Lime kilns were erected at an early date in many settlements where simple plasters or mortar were made by burning the limestone, slaking the resultant lumps with water and adding an aggregate, usually sand, to the mix.

This early plaster was used mainly for surfacing interior walls, usually those of churches, public buildings or larger houses. After considerable experimentation, the most successful mix was a moisture-resistant plaster. It was also used as an exterior surfacing.

Plaster became common in Canada through the Picturesque style in the early 1830s. A British influence, this style of domestic architecture required plain surfaces to serve as a foil for the shades and shadows created by verandah trellis work or adjacent foliage. Plaster maintained its reputation well into the century, for it was able to complement later stylistic developments, such as the Italianate of the 1860s. This style was popularized by the major pattern book of the time *The Architecture of Country Houses* by A.J. Downing. It was revived again early in the 20th century, particularly in connection with the wood framed buildings on the prairies, but this time more for its practical qualities than to conform to stylistic dictates.

2.0 COMPOSITION

All plasters are basically composed of three elements: cement, aggregate and binding agents. The cement may be lime, gypsum or Portland cement; the aggregate usually sand; and the binder wood fibre, clays, coarse hair or straw. Other agents may be added to retard the drying process or to produce special types such as acoustical, moulding or insulating plasters.

Lime is obtained by burning limestone, marble, coral or shells in a kiln to drive off carbonic gases. This produces quicklime which is slaked to form lime putty or, with the further addition of water, to produce hydrated lime.

Gypsum (from the Greek word *gypros* meaning "chalk") comes from pits or mines located in various countries. The rock is crushed, then heated to drive off water content to produce calcified gypsum. This in its purest form is Plaster of Paris – named for the gypsum beds under the city of Paris. It is very quick setting and retardants are added to facilitate workability. The chief source of gypsum in North America, during colonial times, was Nova Scotia (McKee, p. 821).

Portland cement, composed of limestone and clays, is mainly known as a concrete ingredient. It produces a hard, durable coating resistant to water absorption. It is used for interior or exterior surfaces where waterproofing is essential. It is the basis for stucco.

Aggregates, Binders and Additives. Sand was the earliest and the most common aggregate used in plaster. Twentieth-century innovations such as perlite, vermiculite or air entraining agents produce lighter-weight plasters suitable for fireproofing or special products such as acoustical or insulating types. Wood fibre is used with gypsum to add compressive and tensile strength. Other additives include ox blood (to increase hardness), sugar or molasses (to retard setting time) and milk or egg white (to improve plasticity).

2.1 EXTERIOR PLASTER

The essential quality of a plaster for exterior use in Canada is the ability to withstand extreme temperatures. Such early plasters were lime-based using natural cement. Constant efforts were made in the early years to produce a high quality cement (in order to produce better concrete) by varying the mix and the kiln time. By mid-19th century there were several plants in eastern Canada producing natural cement. However Portland cement was also being imported from England where it had been patented in 1824. Since it was found to be stronger than natural cement, it replaced production of the latter by the turn of the century and became the base for the hard, durable plaster now known as stucco.

Stucco, generally regarded as an exterior surfacing material, can be applied over metal lath, concrete or masonry surfaces. Both colour and texture can be controlled, the latter varying from very smooth surfaces scored to resemble stone or brick, to a heavy texture achieved by the coarseness of the aggregate or the addition by machine spray of ground glass or mica bits.

2.2 INTERIOR PLASTER

Interior plaster was lime- or gypsum-based and applied by a trowel in two or three coats: a base or scratch coat, followed by a brown coat and finally the finer grained finishing coat. In two-coat work, which is usually the accepted method, the brown coat is omitted. Total thickness of the finished work varies from about 12 mm to 25 mm (1/2 in. to 1 in.).

In some early construction, the wood trim was applied first and the wall then plastered up to it. Usually, however, plastering was completed before the trimming, a uniform thickness was ensured either by the use of screeds or grounds. Screeds were narrow, 150 mm to 200 mm (6 in. to 8 in.), vertical strips of plaster, spaced 610 mm to 1200 mm (2 ft. to 4 ft.) apart, which were applied first and the intervening spaces then filled in. It was a method customarily used for three-coat plastering, but probably restricted to large and important buildings. More common was two-coat work with guides provided by "grounds" – narrow strips of wood located at floor level and adjacent to door and window openings.

Interior plaster was either applied directly onto the inner surface of exterior masonry walls or, more usually, onto a base of wooden laths. The laths were of three types: fully handsplit, sawn or board. The last (also called an accordion lath) consisted of boards 4 mm to 13 mm (1/8 in. to 1/2 in.) thick, split with irregular spacing, but in such a way that no split ran full width. Those openings were forced apart to provide keying for the plaster coat. Handsplit laths, recognized by their irregular outlines and sawn laths were approximately the same size, about 35 mm wide x 13 mm (1 5/8 in. x 1/2 in.) thick. They were installed horizontally with very narrow spacing.

Sawn laths gradually displaced board and handsplit laths after the mid-19th century and although now almost completely replaced by perforated metal sheets or wire mesh, remained in common use until the 1930s.

Plaster and lath was itself displaced to some extent by the introduction of plaster board in the early 20th century. These sheets of gypsum-based plaster, about 9 mm (3/8 in.) thick, could be nailed to the wall strapping and the joints concealed by a specially designed tape. When painted or papered over, the wall or ceiling had a flat, seamless appearance. With improvements in taping methods, this system has become very popular, particularly for domestic architecture.

Other 20th-century innovations in the use of plaster include the development of acoustical plasters: either very hard and dense, designed to reflect the sound or made with air entraining agents to produce a solid foamlike structure designed to absorb sound. A somewhat similar product has been used for insulation and an insulating gypsum lath made by combining aluminium foil with plaster board.

3.0 BIBLIOGRAPHY

Derry, T.K., and Trevor I. Williams. 1960. *A Short History of Technology*. Oxford University Press, Oxford.

Foster, Michael., ed. 1982. *Architecture, Style, Structure and Design*. Excalibur, New York.

McKee, Harley J. 1977. *Introduction to Early American Masonry*. National Trust for Historic Preservation, Washington, DC.

Rempel, John I. 1980. *Building with Wood*. Revised edition. University of Toronto Press, Toronto.

Ritchie, T. 1967. *Canada Builds 1867-1967*. University of Toronto Press, Toronto.

Watson, Don A. 1978. *Construction Materials and Processes*. 2nd edition. McGraw-Hill Inc., pp. 274-79. New York.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

12.1
PERIOD PAINTING
OIL, WHITEWASH, DISTEMPER, AND OTHER MEDIA

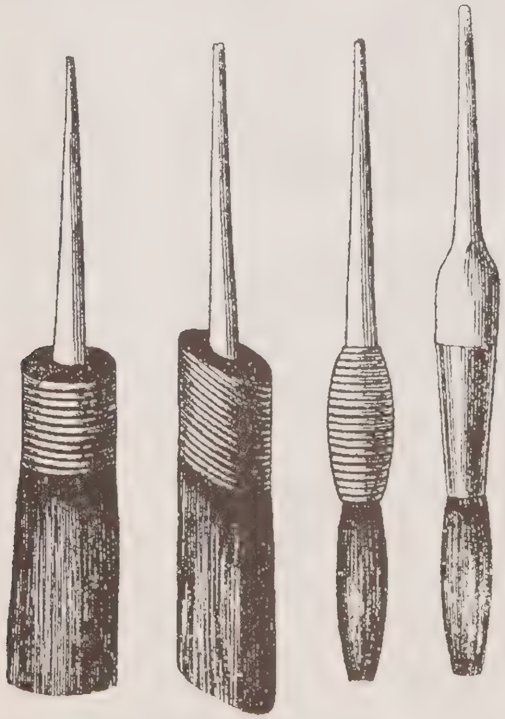
PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: A. KOZLOWSKI

CONTENTS

1.0 INTRODUCTION

The Canadian Parks Service's historic resources include many painted structures which require either preservation of fragile, period painted work or restoration of hard-to-duplicate replica coatings. The purpose of this article is to provide technical staff with basic reference information describing period painting procedures. With this information, it will be possible to provide better analysis of technical conservation problems related to both historic sites development and maintenance. It will also be possible to refer specialized problems to conservation scientists, develop suitable specifications for work and carry out appropriate treatments to ensure the protection of painted historic structures.



Pound brushes (left) were used for most painting in oil, while the smaller sash tools (right) were used for mouldings and sash muntins. (Hawkes)

1.1 DEFINITION

Simply defined, painting is the application of a liquid consisting of vehicle and pigment, which dries to form a decorative and protective coating.

1.2 BACKGROUND

During the 18th century, except for whitewashing, painting was limited to public buildings and to the homes of the wealthy. By the 19th century, raw materials were becoming less expensive and more readily available. Paint was losing its status as a luxury item; its use was encouraged as a practical method for protecting structures from weathering and decay.

Even as late as the end of the 19th century, commercial painting was considered to be an art. Painters were skilled craftspeople who dealt not only with buildings, but with the finishing of carriages, ships, furniture, various forms of ornamental painting, portraits, sign painting and window glazing.

Paints were generally water-based or oil-based. Until the advent of factory production and railroad transportation late in the 19th century, paints were prepared by hand. The process called for hours of tedious labour and exposure to numerous toxic materials.

2.0 TOOLS

The painter required little more than a slab and muller for grinding pigments, a palette knife, earthen pots to hold ground colours, a tin can in which to keep turpentine, a small assortment of mortars and pestles, filtering cloths and different sized brushes.

2.1 BRUSHES

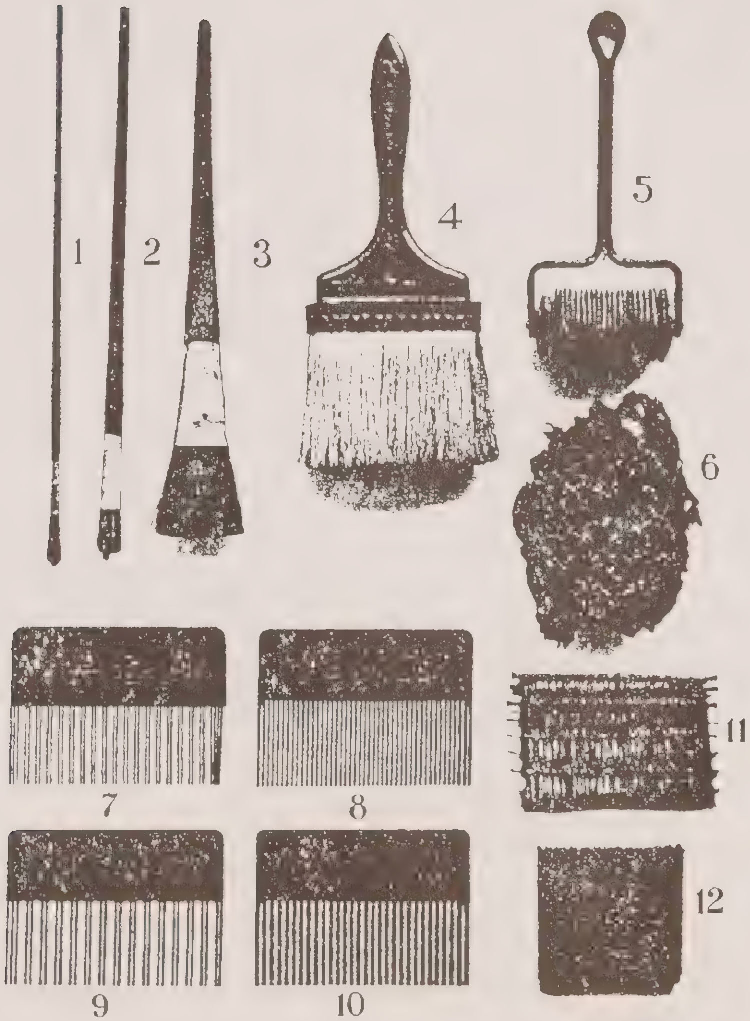
Until the mid-19th century, paint brushes were round; flat brushes were first used strictly for applying varnish.

The best brushes were made of bristles from the backs of wild boars; bristles from domestic hogs were a second-best choice. Holes were drilled in a wooden handle and small bundles of bristles which had been tied together were forced into the holes. Prior to use, the brush was soaked in water to swell the wooden handle, preventing the hairs from falling off.

Tools (Brushes)

1. Stippler
2. Large Overgrainer
3. Short-haired Overgrainer
4. Bone Comb (for separating bristles of overgrainers)
5. Large Mottler
6. Small Mottler
7. Badger Blender
8. Piper Overgrainer

(Hawkes)



Tools

1. *Flat Fresco bristle liner*	7. *Fine Split Steel Comb*
2. *Short-haired Liner, or Fitch Tool*	8. *Medium Steel Comb*
3. *Sash Tool*	9. *Medium Split Steel Comb*
4. *Rubbing-in Brush*	10. *Coarse Steel Comb*
5. *Check Roller*	11. *Selvedge of Straw Matting*
6. *Sponge*	12. *Rubber comb*

(Hawkes)

New brushes might be used for priming or the first coats, but not for finishing. The large pound-brush was used as a duster until the ends were half worn away, rendering it suitable for evenly spreading the colour.

"Fitches" were small brushes used for detail work and mouldings.

"Pencils" were small brushes used for decorative work; they were available in all sizes "from the thickness of a pin to the thickness of a finger." They were made by binding fine bristles together and inserting the tied bundle into the end of a goose quill. The tube of the quill was softened in water and as it dried it contracted and held the bristles securely in place.

3.0 PREPARATION OF PIGMENTS

Pigments were imported mainly from Europe. In urban centres, they were available in paint shops but in remote areas, ingredients might be ordered directly from an importer. Pigments were sold either dry or "ground in oil." Lake pigments were sold in cakes or in a semi-fluid state and some compounds of two or more pigments were imported in oil by the barrel.

3.1 GRINDING PIGMENTS

Grinding machines were introduced in the early 19th century but their use did not become widespread until efficient, inexpensive machinery was available in the latter part of the century.

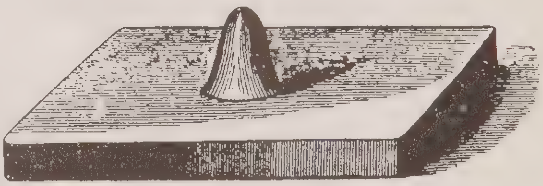
Simple devices such as stone mills and the iron ball and kettle are mentioned occasionally, but it appears that the basic grinding tool was the slab and muller.

The slab was usually a 460 mm to 610 mm square piece of smooth, hard marble or granite, heavy enough to remain stationary. The muller was an egg-shaped pebble stone, broken nearly in half and polished flat at the break. It was usually about 50 mm to 75 mm in diameter with a slightly rounded edge to allow the paint to get under it. The muller had to be tall enough so that it could be grasped with both hands.

Although pigments could be ground dry, they were usually ground in a liquid suited to the type of paint being made. Oil paints were made by grinding pigments in oil. If the desired product were a water colour or distemper, the pigment often could be wetted with water. Pigments intended for use in varnish vehicles could be ground either in oil turpentine or alcohol, although the latter did not work very well because it evaporated too rapidly.

One proceeded as follows:

> ... let the Grindstone (slab) be placed about the height of your middle.... Then take a small quantity of the colour you intend to grind, (two Spoonfuls is enough) for the less you grind at a Time, the easier and finer will your Colour be ground: Lay this two Spoonfuls of the Colour on the midst of your Stone and put a little Linseed Oil to it, (...not too much at first;) then, with your Muller, mix it together a little and turn your muller five or six times about; and ...grind it till it comes to the consistence of an ointment; and when you find you have ground it fine enough, by the continual Motion of your Muller about the Stone, holding it down by hand as your Strength will permit (which you must also move with such a slight, as to gather the Colour under it)... cleanse it off the Stone into a Gallery Pot, Pan or whatever else you design to put it, into and then lay more Colour on your Stone and proceed to grind as before... (Candee, p. 3)



Slab and Muller, used to grind pigments and liquid before mixing paint (Hawkes)

3.2 BURNING AND WASHING PIGMENTS

Some pigments, such as lampblack, umber and flake white, were first burned to rid them of greasiness or to make them dry well. Several others, e.g. red lead, some ochres and chalks, were washed to remove gritty particles:

> Take what quantity of the color you please to wash and put it into a vessel of fair water and stir it about till the water be all coloured there-with; then, if any filth swim on the top of the water, scum it clean off and when you think the grossest of the color is settled to the bottom, then pour off that water into a second earthen vessel full of water four or five times; then pour more water into the first vessel and stir the color that remains, till the water be thick; and after it is a little settled, pour that water also into the second

vessel and fill the first vessel again with water, stirring it as before. Do thus often till you find all the finest of the color drawn forth and that none but coarse gritty stuff remains in the bottom; which when you perceive, then pour the water clear from it and reserve the color in the bottom for use... (Penn, p. 25).

4.0 PAINTING IN OIL

The most well-known binder for period paints was linseed oil. The most popular period thinner was turpentine. Paints were frequently prepared by first grinding white lead in oil, then adding coloured pigments (ground in oil separately from the white lead) to obtain the desired colour.

After grinding, the colours were dissolved in oil and thinned to the proper consistency. Oil naturally dries with a gloss; the larger the quantity of turpentine, the flatter the appearance of the finish.

The heavy use of oil-based paints, the infrequent mention of turpentine, advertisements for "shining colours" and recipes for finishing glazes, suggest that 18th-century finishes were lustrous and bright. On the other hand, the increasing use of turpentine as a thinner for grinding and specifications for "flatting" coats suggest that glossy finishes may have been going out of style in the early years of the 19th century.

4.1 PAINTING WOODWORK

If the wood was dry and the surface had been smoothed, work proceeded as follows:

a. Knotting:
Knots were sealed with "size knotting" consisting of red and white lead ground in water and mixed with size. Alternatively or as a "second knotting," a mixture of red and white lead in oil and turpentine was applied. "Patent knotting," a mixture of shellac in naptha, was available for purchase in later years. Knots were also treated with freshly slaked lime or covered with silver leaf.

b. Priming:
Adding a coat of lead white, with a little red lead added as a drier, well thinned in linseed oil, to permit maximum absorption into the wood surface.

c. Stopping:
After the priming had dried, a putty of lead white and linseed oil was forced into cracks and crevices with a stopping knife.

d. When the putty had dried, the surface was sanded, dusted and one or more intermediate coats of paint were applied. The majority of period handbooks specify three-coat work, but some advocated as many as six coats. In four-coat work:

a. The second coat was thinned with a small amount of turpentine. The third coat, commonly thinned with equal quantities of oil and turpentine, was tinted to the approximate colour of the finish. The intermediate coat was often crossed, that is, brushed at right angles to the direction of the finish coat.

b. If the finish was "flatten," the fourth coat consisted solely of the pigment in a vehicle of turpentine. It was recommended that it be applied while the undercoat was still tacky, to obtain a good bond.

c. Clearcote and Finish was the specification for a cheap interior finish that could be applied to new wood. After "stopping," the surface was covered with a thin coat of whiting and size. The finish coat of lead-in-oil was applied directly over this ground.

4.2 PAINTING MASONRY

Brickwork was painted for various reasons, some practical, others aesthetic. Pressed brick was available early in the 19th century, but it was extremely expensive; its use was reserved only for the street façade. Common brick was used for the other walls of the building and it continued to be painted for protection, just as it had been in the 18th century.

Be it either to give colour or simply to waterproof the brickwork there was always a priming coat that could be:

- one or two coats of linseed oil
- white lead mixed rather thin with raw linseed oil and a little drier
- a special waterproof priming:
  "Dissolve 1 pound gum shellac, $^3/_4$ pound sal soda (sodium carbonate) in 1 gallon of water; when boiling hot, add $^1/_2$ pound of pulverized rosin; stir and when the rosin is all melted, it is ready for use."

Following the priming, either one or two intermediate coats were applied:

a. For a gloss finish, the last coat consisted of the desired pigment mixed with boiled linseed oil and a little drier.
b. For a flat brick effect, the pigment was thinned with turpentine and mixed with a little japan (a short-oil

varnish) usually dark in colour, which produces a hard, glossy surface (*Dictionary of Architecture and Construction*, 1975). [See also Section 12.2.].

The painted brickwork was often "pencilled" with white or black oil paint, to simulate mortar joints.

Where masonry was covered with a sand-lime stucco, it was frequently painted as a form of protection. The stucco might be scored to simulate blocks of stone or marbleized to simulate a more expensive material.

4.3 PAINTING ON PLASTER

Occasionally, ornamental painting was executed on walls coated with oil paint; the work was more durable and could be washed, but required more skill on the part of the painter than did painting in water colours.

> For Painting In Oil On A Wall... when the wall is perfectly dry, give it two or three coats of boiling oil, or more, if necessary, so that the face of the wall may remain greasy, and can soak in no more; then, lay another coat of siccative [sic] colours, which is done as follows. Grind some common whitening, or chalk, red ocher, and other sorts of earth, pretty stiff, and lay a coat of it on the wall. When this is very dry, then draw and paint on it whatever you will, observing to mix a little varnish among your colours, that you may not be obliged to varnish them afterwards (Little, p. 82).

5.0 PAINTING IN WATER COLOUR

Water-base paints were popular with householders because they could be made inexpensively, from materials at hand. The extent and manner of their use is difficult to ascertain for two reasons:

a. Most water-base paints were temporary materials and physical evidence is less likely to have survived.

b. Because the various types of water-base paints are all prepared in a similar fashion, using many interchangeable ingredients, a great deal of confusion exists in determining which coating was actually used in a particular situation. For instance, a coloured whitewash may be referred to as distemper.

5.1 WHITEWASH

Whitewash is basically a liquid plaster composed of slaked lime and water. Salt, glue, sugar or rice flour could be added to somewhat enhance its durability; brickdust, charcoal dust or yellow ochre might be added for colour.

Lime was soaked overnight in a covered container with warm water. Once slaked, the lime was thinned with water and other ingredients might be added. The mixture was applied in the consistency of thin cream with a large horsehair brush. The thickness of the dried coating varied in places, because of the coarseness of the lime and certain additives.

Accounts indicate that most walls in the average home were whitewashed until the advent of wallpaper. Its use was not restricted to interiors, nor to plaster or masonry surfaces. It was applied to fences, siding, roofs, walls, iron work, wood, brick or stucco. It was thought to have a "sanitary influence, as well as being in the highest degree preservative."

5.2 CASEIN

Casein paint consisted of a mixture of casein (a substance precipitated from milk), hydrated lime, hiding pigment and tinting pigments. It dried to form a hard, durable coating which could not be redissolved by water and was therefore relatively permanent. The addition of a small amount of linseed oil made it resistant enough for use as an exterior finish. Pigments which are affected by alkalis, such as Prussian blue or chrome yellow, could not be used with casein paint. This paint dries without a gloss.

Recipes for casein paint began to appear at the turn of the 19th century. It achieved a measure of popularity because it was not as expensive as oil paint and overcame the disadvantages associated with distempers: it dried rapidly and did not have a disagreeable odour; it did not rub off with the slightest friction and was not susceptible to moisture.

5.3 DISTEMPER (CALCIMINE)

In North America, the terms "distemper" and "calcimine" (kalsomine) are used interchangeably to refer to the paint composed of whiting, glue size, water and usually some colouring matter.

Being water soluble, distemper was used indoors, mostly for painting on plaster; it often formed the coloured ground for decorative wall painting. Distemper priming was used as an

inexpensive substitute for priming with oil, but the practice was generally viewed as objectionable, because it was not durable.

The following recipe for water-base paint provides an interesting view of period painting practices.

> Green wash for walls. 4 Roman vitriol (blue ston), 1 span[ish] whiting. Bruise these together. Put them into an earthen vessell and pour on them some warm rain water. Simmer this over a slow fire for three hours stirring it with a stick. Take it off and let it stand. In 24 hours, the ingredients will settle and the water become clear. Pour off the water and it [the wetted whiting] will keep for years ready to mix at pleasure. When wanted it must be mixed with water wherein a small portion of glue has been dissolved, and laid on the walls as many coats as may seem necessary (Little, p. 81).

In 1825, Rufus Porter gave the following suggestions:

> Note, if the glue be dissolved in skimmed milk instead of water it will render the paint nearly water proof.... If the whiting previously be stratified with red beets two or three weeks, it will give the work a beautiful colour without the addition of any other, — a decoction of basswood sprouts may be substituted in place of glue (Little, p. 81).

Usually one volume of melted size was used to two volumes of soaked whiting. Too much water would prevent the mixture from turning to jelly. Too much whiting or pigment would cause the applied coating to crack and flake. An excess of size would give an "eggshell" finish.

Prior to the application of distemper paints, the plaster surface is sealed with a coat of white shellac; premature absorption of the water vehicle may result in an irregular, unattractive appearance. The paint is applied with a broad brush; edges must not be allowed to dry or laps will show. If a second coat is necessary, it should be applied at right angles to the first coat.

6.0 BIBLIOGRAPHY

Candee, Richard M. 1966-67. "Housepaints in Colonial America: Their Materials, Manufacture and Application," *Color Engineering,* Vol. 4, No. 5, pp. 26-29, 32-34; Vol. 4, No. 6, pp. 24-26, 30; Vol. 5, No. 1, pp. 24-26, 30; Vol. 5, No. 2, pp. 32-42.

__________. 1968. "The Rediscovery of Milk-based House Paints and the Myth of 'Brickdust and Buttermilk' Paints," *Old-Time New England (*Winter), pp. 79-81.

Curtis, John Obed. 1980. "How To Save That Old Ceiling," *Old House Journal,* Vol. 8, No. 10, pp. 131, 142-46.

Hawkes, Pamela W. 1983. "Economical Painting," *The Technology of Historic American Building.* The Foundation For Preservation Technology, Washington, DC. Quoted material and illustrations reprinted by permission.

Little, Nina Fletcher. 1952. *American Decorative Wall Painting.* Studio Publications, New York. Quoted material reprinted by permission.

Minhinnick, Jeanne. 1975. "Some Personal Observations on the Use of Paint in Early Ontario," *Bulletin Of the Association for Preservation Technology,* Vol. 7, No. 2, pp. 31-73. Ottawa.

Nicholson, Peter. 1823. *Practical Building and Workman's Companion.* Thomas Kelly, London.

Painters Magazine, The. 1908. *One Thousand More Paint Questions Answered.* The Trade Papers Publishing Co., Ltd., London.

Penn, T.Z. 1984. "Decorative and Protective Finishes, 1750-1850," *APT Bulletin,* Vol. 16, No. 1, pp. 3-46.

Radford. 1909. *Radford's Cyclopedia of Construction.* The Radford Architectural Company, Chicago.

Reynolds, H. 1812. "Directions for Painting," *Antiques (*April, 1978), pp. 850-53.

Weaver, M.E. 1981. "New Paint and Old Distempers," *Canadian Heritage (*December), p. 43.

Welsh, Frank S. 1975. "Paint and Color Restoration," *Old House Journal,* Vol. 3, No. 8 (August), pp. 1, 8-11.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

12.2
PERIOD PAINTING
WAXING, OILING, STAINING AND VARNISHING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: A. KOZLOWSKI

CONTENTS

1.0 INTRODUCTION

This article provides technical staff with basic reference information describing period finishing methods using waxes, varnishes, lacquers and other non-paint media.

2.0 WAXING

During the 18th century, woodwork was often left unpainted. There is reference, in old housekeeping literature, to periodically washing unpainted wainscots with beer. They were then sometimes treated with a solution of ale and beeswax and polished with a soft cloth.

Into the first half of the 19th century, wax finishes were commonly used on woodwork; they were cheap, available and easy to use.

Two forms of purified beeswax were known: the yellow, which contained some impurities but was less expensive and the white, which was clear and preferred for the finest work.

Once the wood surfaces were levelled, smoothed, filled and stained, one could proceed as follows:

> Sometimes they polish with bees wax and a cork for inside work.... The cork is rubbed hard on the wax to spread it over the wood, and then they take fine brick-dust and sift it through a stocking on the wood, and with a cloth the dust is rubbed till it clears away all the clammings.... At other times they polish with soft wax, which is a mixture of turpentine and beeswax, which renders it soft, ... and a cloth of itself, will be sufficient to rub it off with (Mussey, p. 74).

Wax was often melted and applied warm in order to "drive it deeper into the pores" of the wood. A high gloss finish was strived for; wax coats were sometimes built up in the same way as a varnish finish.

At the turn of the 20th century, wax finishes were applied to wood surfaces that were previously stained, filled and shellacked. The treatment was frequently used on floors and trim.

2.1 TYPES OF WAXES

Wax formulas included beeswax dissolved in turpentine, beeswax combined with paraffin and carnauba wax. Carnauba could be used alone if melted by heating and thinned with turpentine. A little colour might be added to wax used on stained woodwork.

2.2 PROCEDURE

A thin coat of wax was laid with a stiff brush. Two coats were recommended for floors. When sufficiently dry, the surface was rubbed to a polish with a weighted fleece or flannel brush.

3.0 OILING

In the 19th century linseed oil was cheap and plentiful and therefore widely used as a finishing.

The process was simple: the oil was applied with a rag or brush, full strength or thinned with turpentine and allowed to soak into the wood. The excess was wiped off with a coarse rag.

After a day's drying time, another coat was applied and ideally this was repeated until the wood no longer accepted the oil.

There are references to tinting polishing oils.

A recipe for an early gloss finish applied to wood trim:

> ...a "tint" should first be given to the raw wood, then "the following should be put thereon with a brush.
>
> Boiled oil, one gallon
> Linseed oil, one gallon
> Best beeswax, 3 ounces
> Turpentine, one quart
>
> When dry the whole should be well rubbed with a coarse woolen flannel, and the oiling repeated as often as necessary, till the degree of polish desired has been obtained" (Minhinnick, p. 14).

3.1 OILED FLOORS

To prepare a floor in this manner, take raw linseed-oil or some cheap oil, not offensive in odour and capable of drying; it can be mixed with a transparent colour such as Van Dyke Brown, umber or burned sienna; apply it with a common paint-brush.

Lay it on smoothly. This may be done at night so that the floor will be ready for use again the next morning. A new coat of oil,

applied in this way once or twice a year, will keep a floor in perfect order (*The Manufacturer and Builder*, p. 203).

At the turn of the 20th century, old-fashioned oiling was still recommended for bare wood, as well as for floors which had been filled, stained and finished with varnish. However, the use of a non-drying mineral oil is suggested, to avoid the fire hazard associated with the careless disposal of rags soaked with linseed oil.

Furthermore, a linseed oil finish is recommended for woodwork subjected to a good deal of wear. The oil is applied in numerous coats and rubbed repeatedly until a high polish, resistant to heat and moisture, is obtained. A satisfactory treatment takes about six weeks.

Linseed oil was sometimes used alone as waterproofing for new pressed brick; it did not give the appearance of a coat of paint, but it did darken the colour of the brick. There is reference to the application of hot oil, which supposedly "makes a fairly efficient preventive of saltpeter stains."

4.0 COLOURING

Today "stain" is defined as a thin layer of coloured pigment lightly penetrating the surface of the wood to which it is applied. "Dye" is any substance producing colour changes by chemical reaction with the wood fibre or by diffusion of the coloured dye-stuff deep into the cellular structure of the wood.

Both 18th and 19th century craftspeople used the two terms interchangeably. More than one hundred different materials were used in colourant formulas; most of them would have coloured the wood in several ways at once. Stains with strongly acidic vehicles or containing material like iron filings, would have coloured by chemical reaction as well as by deposition of pigments. Likewise, many dyes contained pigments which lodged in the wood fibres.

Nearly all the stains and dyes were extremely fugitive; nearly all were based on water, alcohol or mineral spirits.

Besides colouring the wood directly, finishers tinted the waxes, polishing oils and spirit varnishes which they applied to the surface.

5.0 VARNISHING

Varnishes of the 18th and 19th centuries were solvent solutions of resins and gums, which dried to form a hard, glossy film on the surface where they were applied.

5.1 MAKING SPIRIT VARNISHES

Pieces of resin were ground in a mortar or pounded in a cloth bag, then submerged in a glass vessel of alcohol. The resins dissolved if the vessel was occasionally agitated, but placing it in sunlight would speed the process. A varnish pan (a type of tin double-boiler) could be used to heat the mixture over a fire; however, there existed the risk of explosion in the heating process. When the liquid had settled, the top layers were filtered through cotton and used as varnish.

5.2 MAKING FIXED-OIL VARNISHES

This was a complex process because the resins first had to be treated in order to become soluble in oil. Three methods were used: heating the resins to high temperatures called "running," tartarization or infusion. Following this, the resins were ground and dissolved in hot oil.

5.3 APPLICATION OF SPIRIT VARNISHES TO WOOD SURFACES

a. Early 19th-Century Methods:
   Until about 1820, spirit varnishes were thinned considerably, warmed to make them flow out and applied with a brush. Brushes were made of the best quality hog bristle. Round brushes were preferred because they were capable of holding more varnish than the flat-shaped brush.

b. French Polishing:
   The following method of applying spirit varnishes was introduced around 1820 and remained popular for the next century:

   A wad of coarse flannel, wrapped in a soft linen rag, was dampened with polish and rubbed onto the surface with a circular motion. Working an area of about 0.09 m^2 (one square foot) at a time, the whole surface was rubbed until the rag appeared dry; then, the process was repeated again three or four times. A final polish of shellac dissolved in alcohol, with the addition of gum benzoin, was recommended.

5.4 APPLICATION OF FIXED-OIL VARNISHES TO WOOD SURFACES

Generally, four to ten coats were brushed onto a surface. Each layer was allowed to dry thoroughly before the next was applied and each layer was rubbed or polished before being covered over. The following is a summary of the laborious process of applying the "Famous Vernis Martin":

> The procedure starts with the laying on of six coats of varnish, each allowed to dry in a warm room-size chamber, heated with stoves. Then the panel is rubbed smooth with a coarse wet rag dipped in pulverized sifted pumice stone. After the surfaces have been washed, another ten or twelve coats of varnish are laid on, each coat again "stoved." This built-up finish is then rubbed down with the same pumice-stone process as before. A rubbing with fine emery powder follows. The process continues with fine rotten-stone. The final polish is achieved with a rubbing of "water oil" (olive oil) and fine powder or flour. Last, the panel is burnished with fine flannel dipped in flour, giving it a lustre as though it were under a glass... (Mussey, p. 57).

Various abrasive materials were used: sand leathers (soft, wet leather impregnated with sand or tripoli), soft rushes, sealskin, sharkskin, cotton cloth wrapped around a wool cloth and saturated with pumice powder and linseed oil.

5.5 HOUSE PAINTING

In the construction trade, varnishes were applied as a finish on floors and on wood trim and panelling both indoors and out.

They were applied as protective coatings to plaster, wood and metal surfaces which had received a decorative painted finish. To obtain a successful result, varnish was applied at a room temperature of no less than 20°C, to a warm surface. Currents of cold air dulled the varnish. The room where the operation was carried out needed to be kept free of dust until the varnish had set.

6.0 LACQUERING

The majority of lacquers were spirit varnishes coloured either with natural dyestuffs or by the resin alone. They were applied as protective coatings on wood, leather, paper products and metal. When used to improve the appearance of drab woodwork or to give metal objects a more agreeable colour, they were referred to as a "changing varnish."

They were used: where brass was to be made to have the appearance of being gilt; where tin was required to have the resemblance of yellow metals; and where brass or copper locks, nails or other such matters, were to be defended from corrosion of the air or moisture (Penn, p. 33).

Shellac was the dominant resin used in lacquers. Lacquer was applied to any surface with a brush. However, it was also applied to metal objects by heating and dipping or it could be baked on for a hard, lustrous finish.

7.0 JAPANNING

Japanning, as practiced during the 18th and early 19th centuries, was the art of decorating using opaque colours in a varnish binder. It derived from the Oriental process of lacquering and was frequently referred to as "Chinoiserie."

The exacting technique was mostly used on furniture and articles made of metal, leather or paper. There are scattered references to architectural japanning, but only limited examples of its application to plaster wall surfaces and wood panelling.

7.1 PROCEDURE

Priming: a coat of clearcote (whiting mixed in size) was laid on thick enough to hide the substrate.

Next, the ground was applied. Pigment was mixed with a varnish and brushed on. Almost any pigments could be used; shellac was the common binder, but other resins were used for special applications. Several layers of the ground colour would be applied, but only after the preceding layer had dried and had been polished with rushes.

When the ground was finished, decorative figures or scenes could be painted onto it. The work was protected with five or more layers of light-coloured varnish. A final rubbing with pumice and tripoli would give a highly polished finish.

8.0 ENAMELLING

Also known as "china glossing," enamelling consists of building up a finish with multiple layers of paint, the top two or three coats containing varnish as the paint vehicle. It is a late 19th-century technique which evolved from the earlier practice of japanning.

For the most ordinary work, a minimum of four coats was required. Six coats was barely passable and first quality results were obtained with ten to twelve coats, allowing 48 hours between respective applications. In summary, for enamelling new wood:

a. the wood is sealed with one or two coats of white shellac;
b. primer: white lead mixed with linseed oil and turpentine, in equal proportions;
c. one to three "flat" coats of zinc or lead in turpentine or a mixture of lead and zinc in turpentine;
d. one to three coats of pure zinc in damar varnish; and
e. finish: one to three coats of clear damar varnish.

If a tint was required, zinc white could be tinted to the proper shade before mixing with the varnish. The first zinc coat was made darker than the finished work, each successive layer being made a shade lighter than the preceding one. The work was sanded between coats.

The final coat was rubbed with pumice stone and water to a dull, even finish. For a high polish, this was followed by a rubbing with rotten-stone and water or sweet oil.

9.0 GLAZING

Glazing is the application of a tinted, transparent coating to a painted surface, producing a brilliant finish which transmits the tone of the undercoat. It was used on woodwork and plaster surfaces.

> ... glazes made from pigments such as Prussian blue, carmine, yellow lake or verdigris, used over grounds of similar colour. The dry pigment was ground in rubbing varnish without oil, turpentine or japan and was put on like varnish (Minhinnick, p. 129).

The following early vehicle is technically a spirit varnish:

> *A Varnish for All Sorts of Colours.* Take of gum annimiac [ammoniac] 1 ounce, of mastic and gum sandarac of each 2 ounces. Reduce them to a fine powder, put them into a glass vessel and pour a pint of the spirits of wine over them; hang them in the sun or set it by the fire till it is dissolved; then strain it through a clean cloth and keep it in a vial well corked; and then mix your paints with it (Little, p. 6).

Other early recipes for transparent colour are not, strictly speaking, varnishes; water soluble gum arabic is used as the binder.

> *For the red:* Make a lye with salt of tartar. In it, put to infuse for one night, some India wood, with a little alum. Boil all, and reduce to one third. Run it through a linen cloth, and mix some gum-arabic with it. –With more or less alum, you make it of a higher or paler hue (Little, p. 6).

In discussing the paints of Otis House (1796), Morgan Phillips mentioned "thin oil-based glazes" applied over them.

A recipe for making drying oil is given in an early account book: Boil 1 pound (0.5 kg) of red lead, 1/4 pound (0.13 kg) litharge with 3 quarts (3.4 L) of linseed oil until it is as thick as syrup. When cold, the clearest liquid is poured off and should be used one part to three of raw oil.

> ... the drying Oyl... contributes very much ... some good clear turpentine [rosin]... before it be mixt with the Oyl-Colours, shall make those Colours shine when dry, and preserve their beauty beyond all other things, drying with an extream glasey surface and much more smooth than Oyl alone (Little, p. 6).

Glazing was a popular finish at the turn of this century; however, it was used to a different effect than one hundred years earlier. The glaze was tinted to a colour different from that of the undercoat and patterned while wet by stippling, sponging or blending with rags, to create a textured finish.

10.0 GILDING

Writing at the turn of the century, one author defined "gilding" as the art of laying on of gold leaf for the purpose of ornamentation – a decorative technique which can be traced back through history to the ancient Egyptians. However, the author acknowledged that the meaning of the word was changing to encompass the application of all metal leaf, lamenting the fact that it was considered proper to "gild" a surface in aluminium.

Today, gilding can refer to all treatments which produce a metallic finish on the surface to which they are applied. This includes chemical transfer processes, the application of metallic paints and powders, as well as the laying of metal leaf.

10.1 TYPES OF METAL LEAF

10.1.1 Gold Leaf

Gold has been used to embellish and protect the domes of churches, wrought iron fences, carvings and mouldings on building facades. Indoors, it adorns architectural detailing, statuary, wallpaper, murals and furniture.

Gold has been favoured because of its lasting brilliance and durability; it does not tarnish. Unique among metals, it can be beaten to within a few millionths of a centimeter in thickness. In certain light, a gold leaf is partially transparent.

Gold is alloyed with other metals to produce variations in colour. The purest, most widely used gold leaf (24 karat) has a deep, rich tone. The grades run down through lemon-gold (18 karat), pale-gold (16 karat), to white-gold (12 karat).

Gold leaf is placed between sheets of paper and is distributed in books; each book contains 25 leaves, 80 mm square.

There are references from the turn of the century to "Patent" or "Stuck" leaf, a manufactured process whereby the gold leaf is lightly attached to a backing of tissue paper for easier handling.

10.1.2 Silver Leaf

Silver leaf tarnishes rapidly and is therefore little used.

10.1.3 Aluminium Leaf

Aluminium leaf is often used in place of silver because it normally does not discolour. However, its lustre is slightly inferior and its colour greyer. It can be coated with orange shellac to imitate gold or shaded with India ink to suggest tarnished silver.

10.1.4 Tin Leaf

Tin leaf more closely resembles silver than aluminium although it does not tarnish, it loses its lustre and hence is little used except to give a brilliant effect to semi-transparent colourings applied over it.

10.1.5 Dutch Metal or Composition Leaf

An alloy of copper and zinc, it is the oldest substitute for gold leaf. At least three times as thick as gold leaf, it reproduces the gleam of gold and appears only slightly redder in colour. It tarnishes and must be protected by a varnish or transparent lacquer.

10.1.6 Aluminium Gold

Aluminium gold is an alloy of copper and aluminium which is more permanent than any of the other gold substitutes, but for real permanency requires a protective coating of some kind. Another gold imitation is an alloy of copper and tin, which stands about midway between the two previously mentioned.

10.1.7 Copper Leaf

Copper leaf turns a deep rich red or brown unless protected by lacquer or varnish.

10.2 GILDING WITH METAL LEAF

The surface to be gilded is either painted, varnished or coated with gesso in preparation for the application of a suitable size. The nature of the size will influence the durability and the appearance of the finished product.

When the sized surface has been smoothed to perfection and has dried to the proper degree of tackiness, the metal leaf can be applied.

Leaf is laid upon a calfskin leather cushion, cut to size with a gilder's knife and transferred to the sized surface by a soft brush. "Patent" leaf is laid directly onto the size by hand and pressed down gently with the fingers. The tissue is then removed.

When the size is completely dry, rubbing the surface with a cotton ball or soft cloth will produce a flat, lustrous finish. A bright, shiny surface is obtained by rubbing with a burnishing tool.

10.3 METALLIC POWDERS

Metallic powders come in a variety of colours including gold, copper and aluminium. They are widely used in the process of "japanning." Mixed with a suitable vehicle, such as a good quality hard gum varnish, they can be used as a paint.

The surface is first painted, then coated with size. Once the size dries to the proper degree of tackiness, the powder is applied by a ball of cotton velvet or chamois leather. When completely dry, the surface is polished by rubbing with a ball of cotton. A coat of varnish is applied to protect against tarnishing.

11.0 BIBLIOGRAPHY

Innes, Jacasta. 1981. "Gilding" in *Paint Magic*. Van Nostrand Reinhold Co., New York, pp. 192-98.

Jennings, A.S., and G. C. Rothery. n.d. *The Modern Painter and Decorator*. Caxton Publishing Company Ltd., London, pp. 47-51.

Little, Nina Fletcher. 1952. *American Decorative Wall Painting*. Studio Publications, New York, pp. 12-15. Quoted material reprinted by permission.

Lowndes, W.S. 1928. *Painting and Interior Decoration*. International Textbook Company, Scranton, PA, pp. 68-41.

Maire, F. 1910. "Varnishes" and "Varnishing" in *Modern Painters Cyclopedia*. Frederick J. Drake & Company, Chicago, pp. 415-35.

__________. 1910. "Stains and Staining" in *Modern Painter's Cyclopedia*. Frederick J. Drake & Company, Chicago, pp. 390-401.
Discusses the types of stains and provides sample recipes, some of them in use from "time immemorial."

__________. 1910. "Gilding and Bronzing" in *Modern Painter's Cyclopedia*. Frederick J. Drake & Company, Chicago, pp. 215-232.
Technical information and historical perspective on gilding, gilding on glass, bronzing; rambling and incoherent at times.

Manufacturer and Builder, The. 1870. "Oiled Floors," Vol. 2 (May), p. 203.

Minhinnick, Jeanne. 1970. *At Home in Upper Canada*. Clarke, Irwin & Company Ltd., Toronto, p. 129.

__________. 1975. "Some Personal Observations on the Use of Paint in Early Ontario," *Bulletin of the Association for Preservation Technology,* Vol. 7, No. 2, p. 14. Ottawa.

Mussey, Robert D. 1982. "Early Varnishes," *Fine Woodworking,* No. 35 (July/August), pp. 54-57.

__________. 1982. "Old Finishes," *Fine Woodworking,* No. 33 (March/April), pp. 71-75. Quoted material reprinted by permission: Fine Woodworking, The Taunton Press, Newtown, CT.

Painters Magazine, The. 1908. *One Thousand More Paint Questions Answered*. The Trade Papers Publishing Co. Ltd., London, pp. 199-201.

Penn, T.Z. 1984. "Decorative and Protective Finishes, 1750-1850." *Bulletin of the Association for Preservation Technology,* Vol. 16, No. 1, pp. 3-46. Ottawa.

Poore, Patricia. 1979. "Gilding With Gold Leaf," *Old House Journal*, Vol. 7, No. 12, pp. 140-42.
The process of gilding on glass is described in detail.

Radford. 1909. *Radford's Cyclopedia of Construction*. The Radford Architectural Company, Chicago.
Various references to gilding and bronzing techniques; informative, but not very detailed.

Reynolds, R. Wayne. 1980. "Gold Leaf as a Decorative Finish," *Old House Journal,* Vol. 14, No. 10, pp. 151-53.
Excellent. The author, a skilled gilder, provides some historical background, compares modern and traditional materials and techniques.

Stanek, Edward J. 1978. "Gilding" in *Antiques and Art*. Wallace-Homestead, Des Moines, IA, pp. 93-100.
Highly recommended. By means of a detailed description of the gilding of a wooden picture frame, the author clearly explains the elaborate traditional technique of water gilding.

Waring, Janet. 1937. *Early American Stencils*. Dover Publications, New York, pp. 87-92.
Provides a clear explanation of the technique of stencilling with bronze powders.

Weinstein, Nat. 1983. "Glazing" in *Old House Journal,* Vol. 11, No. 10, pp. 215, 229-31.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

12.3
PERIOD PAINTING
DECORATIVE PAINTING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: A. KOZLOWSKI

CONTENTS

1.0 INTRODUCTION

The Canadian Parks Service's historic resources include decorative painted finishes which are frequently unique and demand special skills for protection or restoration. The purpose of this article is to provide technical staff with basic reference information describing types of decorative painting which may have been used on historic structures. With this information, it will be possible to refer specialized problems to appropriate conservators to develop special maintenance programs and to carry out other protective work on the historic finishes.

This article provides a brief explanation of period painting practices for freehand painting, stencilling, graining, marbling, spattering and sanding. It does not cover finishes using waxes, varnish, nor gilding (see Section 12.2). It also does not cover general issues dealing with period painting practices (see Section 12.1).

2.0 FREEHAND PAINTING

Prior to the introduction of inexpensive wallpapers in about the mid-18th century, walls were decorated in varying degrees of opulence, sometimes with scenery and motifs painted directly upon the plaster surface.

> ...the walls may be painted in the resemblance of paper hangings, with trifling expense (Little, p. 81).

2.1 FREEHAND WALL DECORATION

A small number of gifted professional painters created designs in imitation of "stamped paper," directly upon the tinted plaster, without the use of stencils. The patterns were sketched upon the wall, colour applied to the outline and the designs highlighted with strokes of a darker colour. The decoration was less rigid than that obtained with the use of stencils.

2.2 TROMPE L'OEIL

This involves use of the paint medium to create the illusion of three-dimensional objects upon flat surfaces; perspective drawing and shading are used to create the illusion of depth.

Simulated architectural elements – such as columns and arches, curtained windows, wainscotting, cornices or mouldings, etc. – are frequently used in combination with scenic painting and wood-grained or marbled surfaces.

> Chara-obscura (now spelled chiaroscuro) the executing of friezes and the decorative parts of architecture, in chara-obscura or light and shade, on walls or ceilings. It is performed by first laying a ground of the colour required, then sketching the ornament with a black-lead pencil and afterwards painting and shading it, so as to give the required effect (Nicholson, p. 418).

2.3 MURAL PAINTING

True "fresco" painting refers to the laborious ancient technique of painting upon freshly-laid plaster. In America, the term applies to the painting of decorative scenes upon plaster walls which had properly cured and were sized and tinted prior to the execution of the artwork. Occasionally, the painting was done on thin paper applied directly to the walls.

2.3.1 Fresco Painting in Water Colours

The surface preparation is the same as distempering. It involves less expensive wall preparation and is much faster execution than oil painting. It is less durable.

2.3.2 Fresco Painting in Oil

The wall surface is sized with glue, followed by the application of two or more coats of oil-based paint. There are variations which range from the application of the artwork directly upon the sized surface, to the use of three or more coats of oil paint, without the use of size.

The advantage of oil-painted frescoes is that the walls can be washed.

2.3.3 Execution

The design is outlined with carbon pencil; over-drawing is done with a quill pen or a brush.

Sketches are made upon sheets of heavy paper. The outlines are perforated with tiny holes, creating a type of stencil. The paper is held to the wall and powdered charcoal is dusted through the holes. This step is called "pouncing." The outline duplicated on the wall can either be drawn or filled in with colour.

Decorative Wall Painting, Croscup Room, National Gallery, Ottawa, ON

For cheaper work a combination of freehand painting, stencilling and stamping is used, producing a somewhat stylized painting.

2.4 PAINTED FLOORS

The earliest kind of floor ornamentation was freehand work. Simple geometric designs were used; the black and white checkered patterns, in imitation of marble tile, remained popular into the late 19th century. Very basic brush strokes were used to create informal, textured patterns. Intricate painting, in simulation of mosaic tile and woven Persian carpets, has also been recorded.

3.0 STENCILLING

Stencilling is the process of applying decorative motifs by means of a cut-out pattern called a stencil. Intricate designs are difficult to execute using this technique; simple units of decoration, with bold outlines, are most effective.

3.1 EARLY AMERICAN STENCILLING

Stencilling was the common method of decorating walls, floors and furniture in the late 18th century and into the middle of the 19th century. Although it seems probable that good freehand painting was done by professionals, a lot of stencilled work is attributed to amateur decorators.

3.1.1 Tools

A stencilling outfit was simple enough: dry pigments, long-handled round brushes of various sizes, stencils, measuring tools, a builder's cord, a piece of chalk.

3.1.2 Materials

Accounts indicate that distemper grounds were most frequently used and that decoration was also applied in a distemper medium. There is frequent mention of the use of skimmed milk as the vehicle for mixing dry pigments; it was readily available and rendered the painting water resistant.

Decorating was sometimes done in an oil medium, but the materials were more expensive and rare. More important, unlike water colour work, mistakes were not easily washed off and corrected. It was suggested that a little varnish be added to the paint, in order to eliminate the need to varnish the completed painting.

Colour was applied uniformly; designs were never shaded. Colours were probably bright and clear and used in combinations which would be considered daring by today's standards.

Designs were painted onto prepared grounds; infrequently, work was executed directly upon unpainted pine boards.

3.1.3 Stencils

Stencils were usually cut out of heavy paper to which successive coats of oil, paint or shellac were applied. A sharp knife was the essential cutting tool. At times, the edge was bevelled to render a sharper outline. Register marks permitted accurate placing of the patterns.

Stencilling (Old House Journal, *1988)*

3.1.4 Execution

Paint is mixed to a thicker consistency than is required for regular painting. It is applied sparingly to the openings in the stencil, taking care not to smear the underside of the stencil.

For some motifs, a single stencil is used. Elaborate designs require the combination of two or more stencils (one for each colour).

1. A dry brush is dragged over the wet glaze.

2. A soft brush is used to blur lines.

3 The sharp edge of a cork is used to draw heartwood lines.

4 Create a "knot" with the cork edge and draw in grain lines away from it.

The Process of Graining

> Take a sheet of pasteboard or strong paper, and paint thereon with a pencil any flower or figure that would be elegant; …then with small gouges and chissels, or a sharp penknife, cut out the figure completely, that it may be represented by apertures cut through the paper. Lay this pattern on the ground intended to receive the figure, and with a stiff smooth brush, paint with a quick vibrative motion over the whole figure (Little, pp. 76-77).

3.2 VICTORIAN STENCILLING

The art of stencilling, in a more sophisticated form, saw a revival during the Victorian era. Louis Tiffany popularized the use of elaborate forms and vivid colours for floors, walls and even entire rooms. This was work for specially trained craftspeople, not the casual amateur. Unlike the earlier designs, colours were shaded and toned.

The demand for intricate borders around ceilings lasted until the 1940s.

4.0 GRAINING

Graining is imitating the appearance of a desirable type of wood by means of paint. Humble woodwork can be disguised as a more elegant wood. Windows, doors, trim (both exterior and interior) and floors commonly received this treatment because it was durable and easily washed. Simulated wood panelling was also painted on plaster walls and even ceilings. Graining was frequently used in conjunction with other fancy decorating techniques such as marbleizing, gilding or mural painting. It can also be done upon metal and glass.

4.1 EARLY GRAINING TECHNIQUES

It seems that cedar and mahogany were the most popular simulated finishes of the 18th century. The desired effect was soft in texture, achieved by skillfully blending overtones and ground colours.

> Cedar. Take a white lead and India Red, Brown or Red pink, and make dark for the Nots and Grain. Add a little white vitrol and make it dry. The Nots and Grain to be put on as soon as the ground, so that the colours may mix together a little (Little, p. 7).

The patterns of 18th century graining differ from those of the 19th. Early designs were done in large, sweeping strokes by means of a brush. Imitation of actual woods was merely suggested. With the first half of the 19th century came the literal simulations of various woods. Curly and bird's-eye maple were faithfully reproduced; use of the graining comb, rather than the brush, provided meticulous patterns. Designs became more cramped and mechanical; by the late Victorian era, graining had lost its early vigour and charm (Little, p. 8).

4.2 LATE 19TH-CENTURY GRAINING TECHNIQUES

Besides various brushes, grainers use rubber, leather, cork or steel combs, rags, sponges and rollers. For large patterns, they might use "the end of the thumb."

4.3 GROUND COAT

The ground coat consists of white lead and coloured pigments, finely ground in linseed oil. For thinning, use was made of raw and boiled linseed oil, japan dryers and varnishes. Apply two coats of ground colour for normal work. For graining in water colours, the ground is prepared flatter than for oil colour. The ground is tinted to the lightest shade found in the wood to be imitated.

4.4 OIL STAIN FOR GRAINING

Pure beeswax dissolved in turpentine is added to the linseed oil, turpentine and dryers normally used for thinning oil paints. "Megilp" (a thickening agent) is added if necessary to prevent the grain lines from flowing together.

4.5 WATER STAIN FOR GRAINING

Water colours are thinned in clear water, mixtures of stale beer and water, vinegar and sugar or skimmed milk. The stain can be "megilped" if it is too thin or dries too quickly.

The choice of an oil or of a water stain will produce a different effect. A combination of both mediums can be used on the same piece of work.

4.6 EXECUTION

a. Rubbing in:
when dry, the ground coat is evenly covered with a coat of translucent stain.

b. Combing out or wiping out:
removing the applied stain by drawing a rag, brush or comb, back and forth, in the pattern of the grain of wood being imitated.

c. Overgraining:
when the original work is dry, fine darker lines of grain are added. The brushes known as 'blenders' and 'mottlers' are used in this phase.

d. When thoroughly dry, the work is varnished.

5.0 MARBLEIZING

Marbleizing (or marbling) means simulating the appearance of polished stone by means of paint. Indoors, this treatment has been applied to almost every conceivable architectural feature, often in conjunction with other forms of "fancy painting": plaster walls, wood panelling, baseboards, floors and mantels. There is also evidence of early outdoor applications: stucco façades scored and veined to look like marble block, colonial porticos and columns painted like marble. In the mid-19th century, cast iron façades were sometimes marbleized.

5.1 EARLY TECHNIQUES

As was the case with graining, marbleizing of the late 18th and early 19th centuries did not seek to imitate, but rather to suggest the colour and texture of marble. The most common pattern was produced as follows:

> Imitations of marble are produced on white, or light slate colored grounds and the shading colors, – which are ground in oil – are applied immediately to the ground color, and blended therewith before the former begins to dry. The shading used on light marbles is generally a mixture of blue, black, and white, though occasionally green, red and yellow are used; ...In imitating the Egyptian marble, the ground is painted nearly black, and the graining or clouding is formed with various lighter colors (Little, p. 11).

Marbleized Columns. Reconstruction of the Rideau Street Convent Chapel, National Gallery of Canada, Ottawa, ON

5.2 LATE 19TH-CENTURY TECHNIQUES

It became fashionable to paint perfect imitations of marble, in a vast assortment of complex patterns. Painters were advised to closely study real specimens from which to make copies.

Few tools are required: some brushes to lay colours with, artists' brushes for putting in fine lines, badger-hair blenders, feathers for drawing fine veins. For watercolour work: sponges and clean, soft cotton rags can be used.

The ground is laid in two or three coats of white lead in oil, tinted if required, to the predominant colour of the marble being simulated. Clouding and veining is then done in tones lighter or darker than the base colour. Either oil or watercolour mediums can be used. When dry, the work is varnished.

6.0 SPATTERING

In spatter painting, a brush or whisk broom is used to shower flecks of coloured paint onto a tinted ground. The spatter can be applied any number of times, in any number of different colours. The effect produced can simulate the texture of granite, if the spotted pattern is fine and uniform. From the mid-19th century, this was a popular method for decorating floors.

The following directions are given for spattering an exterior surface which has been sanded to imitate stone:

> Mix white lead and oil and after the sand has been sprinkled on, take a little lampblack and oil and dipping a brush into it, strike the brush against a stick held in the other hand, to throw a trifling amount of fine black speckles against the sanded surface (Hawkes, p. 209).

7.0 SPONGE PAINTING

The practice of a "naive" form of this technique dates back to the late 17th century.

A small round sponge, soaked with paint, is dabbed at random upon a background of a contrasting colour. The spotted pattern stands on its own or is combined with simple brush strokes to produce a more sophisticated design.

From about 1850, it was fashionable to overpaint wood floors with a sponge or cloth dipped in a contrasting colour; a combination of various washes and glazes produced a marble-like effect.

The following directions were published in 1888 for reproducing the appearance of mottled brickwork:

> Paint the brick a dark buff color, as near the ground of the brick as you can get; then take burnt unber, raw and burnt siennas and mix those separately in turpentine and dryers. Get a small, nice piece of open sponge and, dipping your sponge in these colors, mottle your bricks separately, regulating your spots according to taste...varying the colors to look like real brick. (Hawkes, p. 207).

Sponge Painting (Old House Journal, *1988*)

8.0 SANDING

Sanding is the process of applying sand to a newly painted surface in order to simulate the appearance of stone.

There are scattered references to this technique being used in the late 18th through the 20th century, the most famous being taken from the writings of George Washington (1799):

> Sanding, is designed to answer two purposes, durability and presentation of Stone; it is the last operation, by dashing, as long as any will stick, the Sand upon a coat of thick paint...as it is rare to meet with Sand perfectly white and clean; all my Houses have been sanded with the softest free stone, pounded and sifted; the fine dust must be separated from the Sand by a gently breeze and the sifter must be of the finess the sand is required.

A sanded finish was a popular treatment for wood, brick and iron during the mid- and late 19th century. Architectural features made of wood, cast iron or sheet metal, such as cornices, trim, railings, verandahs, were coated to harmonize with the solid masonry of the main building. A major selling point for cast iron façades was the ease with which they could be painted to imitate stone.

It was believed that sanding protected the paint from the weather and was highly recommended in all cases. The following is an interesting, contradictory statement:

> The use of red sandstone has lately led to nearly all the houses in the vicinity of New York being painted in a dirty chocolate color, whether built of brick, wood or granite. It is a ridiculous custom, for ...the attempt to imitate... must necessarily be unsuccessful, from the paint presenting a glossy surface. To obviate this defect, a custom prevails of powdering the fresh paint with fine white sand, which produces a very pleasant effect at first; but the rain soon washes off the sand and leaves a wretched aspect to the house (Hawkes, p. 220).

By 1925, sanding was considered to be a thing of the past, because "paint loaded with sand was apt to scale off." The following cannot be passed over:

> Such treatment has been used more extensively on railroad stations than elsewhere to prevent the boys from cutting their initials in the wood with pocket knives (Vanderwalker, p. 134).

8.1 METHOD

In the mid-19th century, paint was occasionally mixed with sand in the container and applied with a brush. This produced a different effect from the process described below.

Specifications generally called for fine, white sand. Common river sand might do for dark colours and crushed stone was also used. For applying the sand, a "hand-sander" was recommended:

> The best are made like a grocer's scoop, with the bevelled part of perforated tin, the holes about one sixteenth of an inch in size and should be made so as to contain, when full, about four pounds of sand. They are filled through the handle, which is stopped with a plug or cork while using (Hawkes, p. 209).

Another device, the bellows sander, was faster, but less reliable.

The substrate was suitably primed. The top coat, prepared with boiled linseed oil, pure white lead, no turpentine and tinted to the colour of the desired stone, was applied.

While the paint was still tacky, sand was thrown or blown onto the surface. Once this coat dried, another might be applied on top of it and sanded. Often the work was scored in imitation of ashlar masonry. Spattering, shading or veining would further suggest the texture of natural stone.

9.0 BIBLIOGRAPHY

Allen, Edward B. 1926. *Early American Wall Paintings.* Century House, Watkins Glen, NY.

Bishop, A., and C. Lord. 1976. *The Art of Decorative Stencilling.* Viking Press, New York.
A contemporary manual which describes basic techniques, measuring and layout procedures, how to create multi-colour designs, using modern materials.

Candee, Richard M. n.d. "Housepaints in Colonial America," *Color Engineering,* pp. 5-6.

Flaherty, Carolyn. 1975. "Early American Wall Stencilling," *Old House Journal,* Vol. 3, No. 1, pp. 1, 8-11.
Provides an historic overview and instructions on how to make stencilled decorations.

__________. 1975. "Victorian Stencilling," *Old House Journal,* Vol. 3, No. 2, pp. 1, 10-11. Illustration reprinted with permission.
Description of the style, where it was applied, how it can be produced.

__________. 1979. "Sand Paint," *Old House Journal,* Vol. 7, No. 9, pp. 104-6.

Hawkes, Pamela W. 1983. *Economical Painting.* The Technology of Historic American Buildings. The Foundation for Historic Preservation, Washington, DC, pp. 208-09, 219-20. Quoted material reprinted by permission.

Hodkinson, Ian. 1982. "Conservation and Transfer of an Early 19th Century Painted Room," *Bulletin of the Association for Preservation Technology,* Vol. 14, No. 1, pp. 20-21. Ottawa.

Innes, Jocasta. 1974. "Painted Floors," *Old House Journal,* Vol. 2, No. 12, p. 8.

__________. 1981. "Spattering" in *Paint Magic.* Van Nostrand Reinhold Co., pp. 176-80. New York.

__________. 1981. "Sponging" in *Paint Magic.* Van Nostrand Reinhold Co., pp. 37-41. New York.
Detailed instructions on how to produce varied effects with a sponge technique; contemporary, not a historic reference.

Jennings, A.S., and G. C. Rothery. n.d. *The Modern Painter and Decorator.* Caxton Publishing Company Limited, London, pp. 77-85.

Jensen, James L. 1988. "How to Glaze Walls and Ceilings," *Old House Journal,* Vol. 16, No. 1. Brooklyn, NY. Illustrations reprinted by permission: OHJ, Gloucester, MA.

Labine, Clem. 1983. "Stencilling Secrets," *Old House Journal,* Vol. 11, No. 5, pp. 97, 108-10.
Detailed instructions on how to produce stencilled decoration, using contemporary techniques and materials.

Lipman, Jean. 1951. *American Folk Decoration.* Dover Publications, pp. 96-99. New York.

Little, Nina Fletcher. 1952. *American Decorative Wall Painting.* Studio Publications, New York, pp. 76-79. Quoted material reprinted by permission: Viking Penguin, a division of Penguin Books USA Inc. Virtually the whole book is devoted to a survey of pre-1850s free-hand wall decoration. It is a study in art history which provides very little technical information.

Loth, Calder. 1977. "A Mid-Nineteenth Century Color Scheme," *Bulletin of the Association for Preservation Technology,* Vol. 9, No. 2, pp. 82-88. Ottawa.

Lowndes, William S. 1928. *Painting and Interior Decoration.* International Textbook Company, Scranton, PA, pp. 58-59.

Maire, F. 1910. "Stencils and Stencilling" in *Modern Painter's Cyclopedia.* Frederick V. Drake & Company, Chicago, pp. 402-14.
Interesting account of how to make and use stencils, including a discussion of materials relevant to the Victorian period.

__________. 1910. *Fresco Painting: Modern Painter's Cyclopedia.* Frederick J. Drake & Company, Chicago, pp. 206-14.

__________. 1910. *Marbling: Modern Painter's Cyclopedia.* Frederick J. Drake & Company, Chicago, pp. 260-73.

__________. 1910. *Graining: Modern Painter's Cyclopedia.* Frederick J. Drake & Company, Chicago, pp. 235-58.

Martin, Gina. 1973. "Stencilled Wall Designs," *Bulletin of the Association for Preservation Technology,* Vol. 5, No. 3, pp. 63-65. Ottawa.
Detailed instructions on how to record and preserve old stencilled decoration and how to reproduce it on a historic site using modern materials.

Matero, Frank G. 1983. "A Rare Example of Early 19th Century Trompe L'Oeil Decoration," *Bulletin of the Association for Preservation Technology,* Vol. 15, No. 3, pp. 34-38. Ottawa.

Minhinnick, Jeanne. 1970. *At Home in Upper Canada.* Clarke, Irwin & Company Ltd., Toronto, pp. 125-36.
A very brief look at the history of stencilling in a Canadian context. Some illustrations.

Mora, L., P. Mora and P. Philippot. 1984. *The Conservation of Wall Paintings.* Butterworths, London.
Includes three chapters devoted to the history of mural painting techniques: pre-history to classical antiquity, the middle ages, the renaissance to the present. Discusses materials, types of substrate, methods of execution.

Moss, Roger. 1981. *Century of Color.* The American Life Foundation, Watkins Glen, NY, p. 10.

Nicholson, Peter. 1823. *Practical Builder and Workman's Companion.* Thomas Kelly, London.

Old House Journal. 1975. "Marbleizing," Vol. 3, No. 3, pp. 8-9.

Peterson, Charles E. 1950. "Early American Sanded Paint Finish," *Journal of the Society of Architectural Historians,* Vol. 9, No. 3, p. 24.

Radford. 1909. *Radford's Cyclopedia of Construction.* The Radford Architectural Company, Chicago, pp. 137-47.

Reynolds, H. 1812. "Directions for Painting," *Antiques* (April, 1978), pp. 850-53.

Stank, Edward J. 1978. "Stencilling" in *Antiques and Art.* Wallace-Homestead, Des Moines, IA, pp. 247-49.
The conservator's method of reproducing a missing stencilled decoration on a piece of furniture. Informative.

Vanderwalker, F.N. 1925. *House Painting Methods.* Frederick J. Drake & Co., Chicago, p. 134.

Wall, William E. 1937. *Graining, Ancient and Modern.* Frederick J. Drake & Co., Chicago.
A manual written by a craftsman who was an outstanding authority in his field. Tools, methods, materials used for countless types of graining are explained in detail. Contains a number of coloured illustrations. An excellent reference.

Waring, Janet. 1937. *Early American Stencils.* Dover Publications, New York.
Includes a short history of stencilling on walls, floors, and furniture; some information on tools and materials. It is an important review of patterns and their arrangement, based on the author's extensive field research. Contains numerous illustrations.

Welsh, Frank. 1973. "Report on an Early Wall Stencil in Philadelphia," *Bulletin of the Association for Preservation Technology,* Vol. 5, No. 2, p. 55. Ottawa.
Description, illustrations (including full size drawings) of a design recorded by the author.

__________. 1975. "The Peter Wentz House," *Bulletin of the Association for Preservation Technology,* Vol. 7, No. 2, pp. 124-30.

Zucker, Howard. 1975. "How to Grain Like a Professional," *Old House Journal,* Vol. 3, No. 6, pp. 1, 8-11.
An impressive photographic record and written description, but no technical information.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

13.1

PERIOD SERVICING

PLUMBING AND DRAINAGE

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

Plumbing and drainage systems are the most recent basic convenience in the home or workplace. Indeed, running water systems have been established in Canadian urban centres for barely 150 years and even these followed on only 40 years' experience of cities like London. Plumbing systems were not universally adopted in all parts of a town or in all urban areas at the same time. Many buildings now being considered for period restoration did not originally have indoor plumbing. Often the provision of plumbing fixtures and bathrooms was the reason for additions or major renovations to existing buildings. It is therefore important to place the development of these systems in its proper context.

A plumbing system consists of:

- a supply of water
- a distribution system
- provision for heating the water
- arrangements for wash disposal and venting
- plumbing fixtures.

The purpose of this article is to provide an historical overview which will assist those involved in period restoration projects. This manual is a companion to Vol. III.6.1 "Period Plumbing and Drainage."

2.0 HISTORICAL DEVELOPMENT

Like heating and ventilating, sophisticated plumbing and drainage systems were known from ancient times. As early as 1700 BC, an elaborate plumbing system serviced elegant baths in the Palace of Minos on Crete. The ancient Greeks, who were concerned with fitness and health, promoted good sanitation. The Romans developed such a complete approach to sanitary systems that much of current terminology is based on the Latin language. Extensive underground public water supply systems were supplied by immense aqueducts. Baths were provided with hot water delivered in lead or bronze pipes. The largest of the public baths, which could accommodate over 3000 people, became places for socialization and relaxation. These systems were constructed in varying degrees of sophistication throughout their territories but all this technology came to an end with the collapse of the Roman empire.

Pump and Carriers

From the 6th to the early 19th century, drainage took the form of open sewer ditches. Water was drawn by hand and later pumped to holding devices (buckets, cisterns); fixtures were portable (washtubs, bowls, baths) and they were not associated with a particular room. Waste disposal consisted largely of tossing it out the nearest window. As a result, urban water supplies were badly polluted, rats and vermin abounded and diseases like the bubonic plague, typhoid and cholera ravaged cities and towns everywhere. The wealthy habitually migrated from built-up areas to escape these evils.

Prior to the mid-19th century, water had to be brought into the house by hand to be used for food preparation, dishwashing or personal hygiene. Wooden, metal, stone or porcelain tubs, pitchers, bowls and buckets were used for this purpose. Furniture appropriate to their function was designed: the dry sink, the washstand and the commode are examples of this kind of furniture.

Water closets were reintroduced during the 12th century, but their use was rare and earth-pit privies were the norm. Attempts to improve the system were not made in earnest until Englishman Joseph Bramah invented the valve closet. The pan closet (1833) and the long and short hopper water closets (ca. 1850) utilized water reservoirs. The next major innovation was the washdown water closet (1880) which featured siphonic action. This was an American invention whose sanitary qualities rendered all previous models obsolete. Elevated water tanks provided the water supply until 1915, when the flush tank was positioned just above the water closet. Finally in the 1930s a one-piece water closet and flush tank unit was introduced.

The growth of cities in the late 18th and early 19th centuries forced the open ditch sewers underground. In 1728 the first American underground sewer was laid in New York City. Although this improved the aesthetics of the streetscape, the system continued to pollute the water systems and potable water was sold door to door. People still continued to dump waste and refuse into the streets; therefore, catch basin grilles had to be installed to trap materials swept down into the sewers by rain. It was not until the mid-19th century that the relationship between sanitation and health received widespread attention and adequate public water supply and waste disposal systems were demanded.

3.0 PLUMBING

3.1 WATER SUPPLY SYSTEMS

The first water supply systems were private, often operating in conjunction with large rainwater storage tanks or cisterns. There were three types of cisterns:

a. wooden or metal located either in the attic and operating on a gravity system or in the basement and functioning with the aid of a pump;
b. masonry tanks built into basement foundations; and
c. masonry lined pits buried a few feet from the house. The latter provided the best protection from freezing. Attic installations required adequate overflow mechanisms to avoid damage to the rest of the house in the event of too much rain.

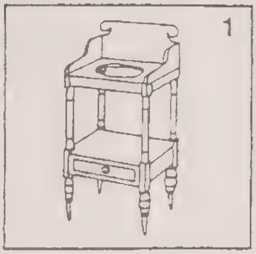
Public water supply systems provided water to individual homes from reservoirs or by pumping directly from a nearby source or from distant aqueducts. Originally wooden pipes were used, but these were soon replaced by metal. Use of the public system was slow to start with even though the general public was pleased to have the fire protection it afforded. In Philadelphia, a public water supply system was available in 1802 and in New York a pressurized system was introduced in 1842. In 1855 hookup to a filtered water supply system was made compulsory throughout the districts of metropolitan London. The proliferation of plumbing systems, which arose from the pure air and domestic science movement in the last half of the 19th century, resulted in many complex innovative piping systems. The less successful private systems could foul the public system. This prompted the establishment of plumbing inspectors. Sometimes these individuals were assigned multiple duties. In 1885 the Sanitary Inspector in Carleton Place, Ontario, was also the Chief Constable, the Street Commissioner and a tax collector.

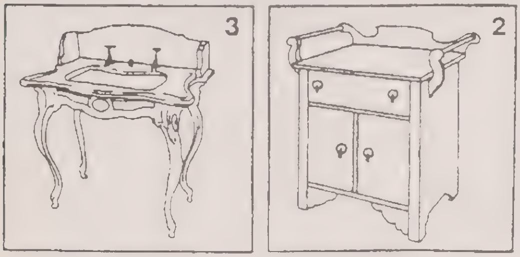
3.2 DISTRIBUTION THROUGH THE HOUSE

Pipes for the distribution of water through the house were run from the basement, where the connection was made with the water main in the street. This connecting pipe was at least 19 mm ($^3/_4$ in.) in diameter, although 6 mm ($^1/_4$ in.) pipe was recommended to supply adequate water to more than one faucet at a time. A shut-off valve was installed just inside the house and provision was made for a drainage lock at the lowest level of the system. Care had to be taken to prevent the pipes from freezing and most were wrapped with insulation. If uncovered, hot water pipes were kept 150 mm (6 in.) away from cold water pipes. When installed in already constructed homes, these pipes ran throughout the house along the outside of the walls, although in some cases they were enclosed in boxes.

The advent of plumbing systems, as well as innovations in heating and ventilation during the last half of the 19th century, resulted in new room allocations within the house. These changes were made to align plumbing facilities as much as possible in a straight line (both vertically and horizontally) to reduce the amount of pipe required and increase the efficiencies of the flow.

1) This washstand, circa 1840, reflects popular furniture styles of its era. The hole in the top accommodated a porcelain wash bowl.
2) Side towel bars and a lower cupboard for storing the chamber pot characterize this Victorian-era washstand. The next evolutionary step would be . . .
3) . . the early bathroom lavatory. This typical example has the basin set in its top and attached running water faucets.





Washstands (Old House Journal, *1986*)

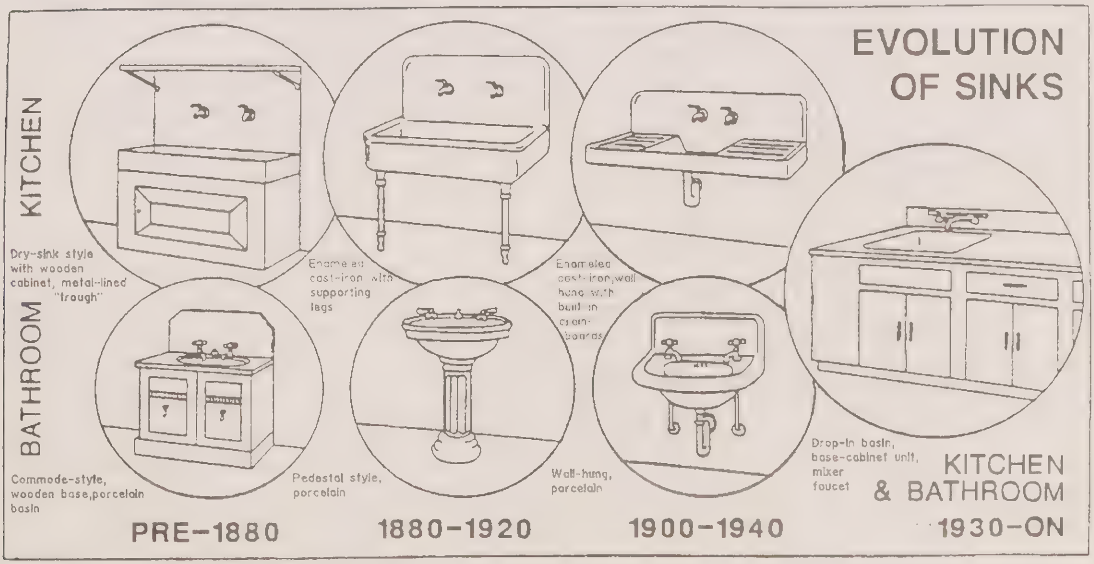
3.3 HEATING THE WATER SUPPLY

Heating the hot water supply depends on the amount required for daily use in the kitchen, laundry and bathroom. Unlike hot water for heating systems, it does not need to be generated continously. Several methods were used. Where gas or electricity was available, quick acting heaters could heat storage tanks; these were eventually made of copper to avoid the rust problems common with other metals. These could be hand operated or automatic. If a coal furnace was used for heating, a hot water coil or fireback could be installed and connected to the storage tank to provide a constant supply in the winter months.

4.0 FIXTURES

4.1 SINKS

Wooden wash tubs and porcelain bowl-and-pitcher washstand sets were the early antecedents of the sink. They were portable and so could be moved anywhere. Once water was available via a cistern, a gravity system or a public water supply, these portable fixtures were connected by means of pipes and became the modern sink.



Evolution of Sinks (Old House Journal, *1986*)

4.1.1 Kitchen Sinks

The wooden washtub was the first to become a fixed piece of furniture. The dry sink was a low, plain wooden cabinet with a recessed top and a splash board. Sometimes it was lined with metal. Popular in North America from 1820 to 1900, it was also used with pump or faucet attachments in rural areas well into the 20th century.

The kitchen sink, like all other plumbing fixtures, benefited from the "pure air" and "domestic science" movements. Wooden sinks were replaced with models in a wide variety of sanitary materials: cast iron, enamel, porcelain, china, galvanized iron, zinc, tin and soapstone.

Enamelling of cast iron was introduced around 1872; production on a volume basis began in 1874 and by 1900 enamelware was the most popular kitchen sink model.

Early sinks were free-standing, often on cast-iron legs painted to match the enamel or porcelain. Later models offered the option of hanging on the wall. In the 1920s, designs became more streamlined to avoid creating dirt-catchers, although drainboards were still a prominent feature. Drop-in sinks appeared during the 1930s, accompanied by continuous counter tops. This development has been partly attributed to the influence of progressive schools of architecture such as the Bauhaus which promoted simple, uniform designs.

4.1.2 Lavatories

The first washstands were small tables equipped with splashboards and perhaps a shelf for a chamber pot. Later they were transformed into larger commodes, often having towel bars, with cupboards to discreetly conceal the chamber pot. With the introduction of running water, the bowl was often dropped into this piece of furniture and connected to the system. Later enamelware or porcelain sinks were supported on pedestals or hung from the wall to allow for more floor space. The first major innovation was the provision of an overflow pipe on the outside and this was followed by an integrated overflow built into the basin.

While white was the early colour preference, by the 1920s colours were available.

4.1.3 Faucets

The first faucets were levers directly connected to a valve in the water line. They had two positions – on or off. These were superseded by compression-valve faucets in the late 19th century which allowed a continous flow of water over a range of flow from fully on to completely off. By 1915 spray attachments were available and in the 1920s mixer connections which allowed hot and cold water to be mixed and exit via a single spout were popular. The electric dishwasher, which connected to the kitchen faucet, was introduced in the 1920s as well.

4.2 WATER CLOSETS

Water closets were used in ancient times but were not reintroduced until the 12th century. However, their use in the middle ages was rare. In 1788 the process started again when an Englishman, Joseph Bramah, developed what he called the valve closet. This was improved to include a flushing rim. There was a deep bowl that was flushed and refilled by the operation of a valve controlled by an air cylinder. The water pressure was provided by a Bramah pump. This type of water closet was used for many years in railway cars.

The English continued to contribute major innovations until the late 19th century. In 1833, the pan closet was developed. Much cheaper to produce than Bramah's model, it continued in common use for almost forty years. This type featured a deep lead bowl with a hinged copper pan that held water in the bowl to form a seal. Dumping was achieved by a hand crank. The bowl was flushed by opening a valve in the water line. The water was supplied from an elevated storage tank usually located in the attic.

During the 1850s the *long hopper* and then the *short hopper* (used in frost-free areas) were introduced. They were made of glazed pottery and shaped like a hopper which discharged into a trap located beneath the floor. Flushing was accompanied by a valve, located beneath the floor in the water line, directly connected to the bowl. This valve was operated by a rod connected to the underside of the seat. The bowl was flushed continuously from an elevated tank throughout the time the user sat on the seat. In the short hopper closet, the joint between the bowl and the trap flange was made with putty and secured by clamps. In 1870 a *plunger closet* was developed and widely used in frost-free areas, but it required frequent repairs and maintenance.

Washout Closet (Sears, Roebuck Catalogue, 1908, *P. 605*)

Low Down Closet (Sears, Roebuck Catalogue, 1908, *p. 605*)

The first all-earthenware water closet, the *washout closet*, was introduced around 1880. This was a major innovation not only because the materials made it more sanitary, but because, for the first time, the seat was attached directly to the top of the bowl, eliminating the need to install a framework with legs to support it above the bowl. This design also had better flushing capabilities because the tank was located on the wall approximately 1.5 metres (5 feet) above the fixture.

The next major innovation, the *wash down water closet*, rendered all others obsolete. It was invented in the United States in 1890. Similar to earlier models, it was made entirely of earthenware. The seat was attached directly to the bowl and an integral S-trap. In addition, some models had "siphonic action" which, coupled with deeper water in the bowl and therefore greater coverage of the interior bowl surfaces, permitted complete scouring of the interior with each flushing. This eliminated foul and odorous conditions after frequent use. Utilizing the S-trap and 30 litres (8 gallons) of water from an elevated tank, a siphon-type flush valve siphoned at least 23 litres (6 gallons) from the tank each time. Several years later the first automatic flush valve, the flushometer, was on the market.

In 1915 the lowdown flush tank was introduced. This consisted of a floor outlet type washdown water closet and a porcelain flush tank installed just above the top of the water closet. Further refinements were made in the period 1916-20 when the design of the reverse trap water closet increased the surface area of the bowl covered with water. One-piece water closet bowl and flush tank units appeared in the 1930s. This type operated almost completely silently. It featured a quick action ball cock in the flush tank. The bowl was designed to create a rotary movement which permitted increased scouring action and complete siphonage of the contents of the bowl.

Around the turn of the century American pottery makers produced glazed vitreous chinaware with a smooth impervious surface ideal for plumbing fixtures. As a result, many individual pottery, enamel and founding firms combined to become large plumbing fixture manufacturers. Glazed terra cotta fixtures were popular for a while but faded from fashion because their relatively heavy weight required too much support.

4.3 BATHTUBS

Early bathtubs were made of wood and often lined with sheet metal (lead, copper, or zinc). Both the interior and exterior were usually painted white or cream to conform to current concepts of sanitation. Because bathing was not a popular pastime, there was no pressure to give the bathtub a room of its own until the late 19th century.

Early bathtubs were brought near the fire for the occasion. However in the 18th and 19th centuries, the bath was often disguised as a piece of furniture. It was filled by hand. French slipper tubs had a seat in the "heel" and beneath was a grill where charcoal was burned to heat the water in the tub.

The introduction of enamelware in 1872 made bathing a more pleasant experience. The enamel cast iron was not easily dented, had no seams to leak and there were no unsightly corrosion marks. These tubs were smooth, comfortable and appropriately white.

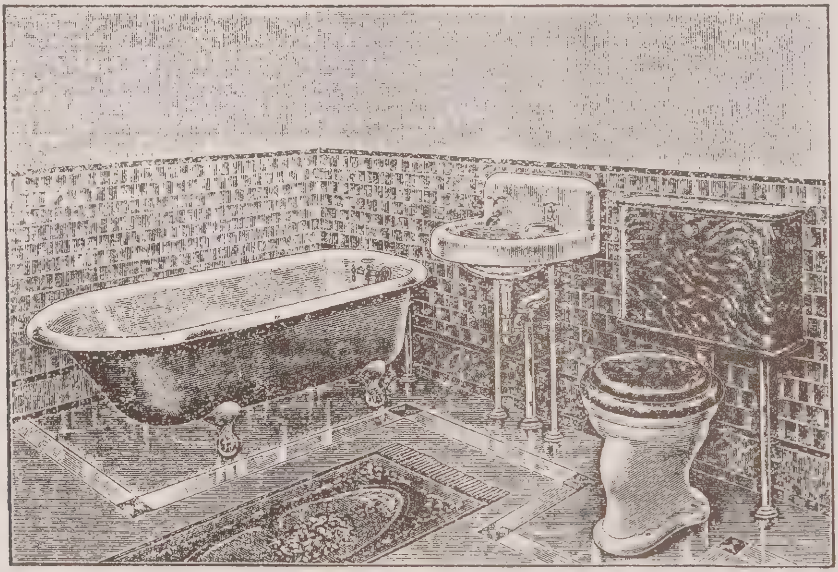
By 1874 they were being mass produced. Once bathtubs were ensconced in the bathroom with running water they still remained free-standing, often on elaborate legs. However, the emphasis on sanitation, a powerful force in the late 19th century, resulted in tubs being built into the wall on at least two sides and encased to the floor to prevent dust and dirt catcher areas under the fixture. Porcelain was also rolled over the rim and down the outside to provide a more sanitary surface. Some tubs in the Victorian era were elaborately encased and treated like a piece of furniture. Nevertheless in the 19th century bathing was a relatively novel concept. Manufacturers marketed their products with regal names and with slogans such as "cleanliness is next to godliness." In the 20th century bathtubs became more streamlined, as did other plumbing fixtures.

5.0 DRAINAGE

5.1 DRAINAGE SYSTEMS

The success or failure of any drainage system depends on the surrounding soil conditions. Anything which interferes with the efficient dispersal of water through the ground must receive careful attention. Poor drainage can destroy natural and artificial landscapes, cause unsettling soil conditions, pollute water supplies and cause problems like efflorescence in masonry walls.

In the case of home drainage systems, the main soil pipe, usually 100 mm (4 in.) diameter, was placed under the basement floor and given a pitch of two percent. These house drains were made of extra heavy cast iron. The joints were packed with oakum and then closed tight with soft pig hammered into the hub at the joint. Branch pipes were made of galvanized wrought iron or lead and the exposed pipes were brass and were nickel plated or painted depending on the location.



"Bathroom Outfit" (Sears, Roebuck Catalogue, 1908, *p. 604)*

5.2 ARRANGEMENTS FOR WASTE DISPOSAL AND VENTING

Interior plumbing fixtures require a method of disposing the waste materials and venting the gases they create. Exterior storm sewers were used in the 18th century. Most buildings were equipped with some means of conducting rainwater off the roofs to gutters which carried the water away. Storm sewers were constructed with stone floors and vaults and masonry walls. Early waste and refuse problems were solved by the installation of catch basin grates in the early 18th century. When interior plumbing systems required disposal, most cities opened up existing storm sewers to serve this dual purpose. Most communities now separate storm sewers and sanitary sewers.

Two major factors had to be considered when installing a waste disposal system. First, the system had to be kept as simple as possible. Facilities were therefore grouped together and stacked where possible vertically throughout the various levels of the structure. This allowed for a single stack system. Secondly, there was a need for proper venting.

A typical system included the access pipe to the main sewer system, a trap located just inside the house to prevent backup and a fresh air vent.

The waste pipe was attached to this access pipe and branches led to each fixture. Initially a vent pipe was considered essential to this system. A 50 mm (2 in.) vent pipe was run off the main pipe at the bottom, through the system parallel to the main pipe and connected to the trap of each fixture. After the last fixture, it was reconnected to the main pipe and vented through the roof. In a system without back-venting, the old fashioned S-trap had a connection to the roof for venting. This kept the water from being siphoned out by using water as a seal to keep the gases from coming up through the outlets in the fixtures. Non-siphoning traps were developed to avoid the need for venting.

5.3 CESSPOOLS AND SEPTIC TANKS

Where public sewers were not accessible, waste vaults were used to handle sewage wastes. These had to be cleaned out on a regular basis. Cesspools were later used to filter wastes through loose gravelly soil. However, the liquids could drain off and pollute water supplies and the solids gradually accumulated and clogged the system. Eventally even the liquids would not be able to disperse and a new cesspool would have to be dug.

The septic tank solved most of these problems. It is generally used today. This consists of an hermetically-sealed concrete box where bacteriological action is constantly breaking down the solid matter and rendering it harmless. The liquid overflows the tank and disperses. When used in conjunction with a disposal field, the liquids are discharged through radiating drain tiles set below the surface at a depth of 300 to 460 mm (12-18 in.). These tiles have open joints or other means of dispersing the liquids over a wide area.

6.0 CANADIAN CONTEXT

Canadians produced few original concepts in the field of plumbing and drainage. The use of various systems and fixtures invented elsewhere was largely dependent on when municipal water supply systems were introduced in each area and when it became socially acceptable or compulsory to hook up to the system.

Municipal water supply systems were established in Saint John, NB, and Halifax, NS, in 1838 and 1848, respectively. They operated on the gravity system. In 1841 and 1850 pumping stations were established in Toronto and Kingston, ON. In 1841 a private firm, the City of Toronto Gas Light and Water Company, was drawing water from Lake Ontario through wooden pipes. By 1858, Toronto had only 24-32 km (15-20 miles) of water lines for over 160 km (100 miles) of streets. Furthermore, the fee for hooking up to the sewer or water lines discouraged their use. Thomas Keefer designed a system for Hamilton, ON, in 1859 and another in Ottawa, ON, in 1874. In Ottawa a second well was not dug until 1840, a pump was added in the market area in 1843 and in 1865 the Parliament buildings were served from a large wooden conduit immersed in the Ottawa River. A steam engine pumped the water through a filter to a tank in the basement; from there it was raised to cisterns located in the towers. By 1870 most major urban centres were using steam-pumped systems.

Despite the availability of municipal water lines and sewage systems, few cities considered them a sign of progress and therefore worthy of the political backing essential to extending the systems and requiring hook-ups. Until the late 1880s, a collective social response to social welfare or public health was not evident.

Both Ottawa and Toronto were obliged to improve their health standards under the terms of the *Provincial Health Act* in 1884, but this had little effect on water works and sewage. They both continued to draw water from polluted sources. Vancouver, BC, which was both founded and rebuilt in 1886 after a fire, was one of the few cities to have municipal backing for progressive water and sewage systems. In the prairie city of Saskatoon, SK, drainage, sewer, water and electric light systems were not installed until 1909.

7.0 BIBLIOGRAPHY

Andrews, Margaret W. 1984. "The Best Advertisement A City Can Have: Public Health Service in Vancouver 1886-1888," *Urban History Review*, Vol. 12, No. 3 (February), pp. 19-27.
Outlines the development of the public water system in Vancouver with brief reference to the situation elsewhere in Canada.

Anon. 1904. *James Robertson Co. Limited Catalogue E.* Montréal.
An interesting and well illustrated catalogue of plumbing supplies including bathtubs, sinks and appropriate pipes, available from this Canadian company. 394 pp. Illustrated.

Atlantic Monthly Company, The. 1925. "Plumbing," Part IV: Mechanical Equipment, Chapter XVII in *The House Beautiful Building Manual.* Boston, pp. 99-102.
This article outlines the five basic elements of a plumbing and drainage system in clear terminology. Illustrated.

Brigaux, Guy. 1970. *La plomberies, les équipements sanitaires.* 5th edition. G.B. and Maurice Garrigou. Edition Eyrolles, Paris.
Well-illustrated guide to plumbing equipment in France.

Clow, George B. 1906. *Practical Up-to-date Plumbing.* F.J. Drake, Chicago.

Cotton, J. Randall. 1986. "Sinks" *The Old House Journal.* Vol. 14, No. 6 (July-August), pp. 270-78. Illustrations reprinted by permission: OHJ, Gloucester, MA.
An interesting overview of the evolution of sinks and piping in America with suggestions for their maintenance and repair. Good illustrations.

Feuerstein, P.E. 1983. "Things You Should Know About Old House Plumbing," *The Old House Journal,* Vol. 11, No. 7 (Aug-Sept), pp. 133, 158-61.
This excellent article outlines plumbing basics and includes charts which deal with the problems, causes, cures and comments regarding water supply and waste piping. A glossary of plumbing terms is also included. Illustrated.

Ives, F.W. 1921. "Land Drainage: How it Affects Architecture and Landscape Architecture," *Architectural Forum.* Vol. 35, pp. 55-58.
This article outlines the importance of proper drainage to the successful construction of buildings and outlines the principal types of drains. Illustrated.

Kidder, Frank E., and Harry Parker. 1936. "Hydraulics, Plumbing and Drainage, Gas and Gas Piping," Chapter XXXII, in J.J. Cosgrove. *Kidder-Parker Architects' and Builders' Handbook Data for Architects, Structural Engineers, Contractor and Draughtsmen.* 18th edition. John Wiley and Sons, Inc., New York, pp. 1717-76.
This book, which was first published in 1884, provides a comprehensive description of heating and ventilating systems along with numerous charts and illustrations.

Nielsen, Louis S., P. Eng. 1982. *Standard Plumbing Engineering Design.* Second edition. McGraw-Hill Book Company, New York.
An excellent volume which deals with the entire gamut of plumbing and drainage from its early history to modern times. It outlines the objectives and requirements of old and new plumbing fixtures and water supply systems.

Smith, James M. 1983. "Cisterns," *The Old House Journal,* Vol. 11, No. 9 (November), pp. 209-11.
An excellent article on the restoration and maintenance procedures for old cisterns. Well illustrated.

Standard Ideal Co. Ltd. n.d. *Cast Iron, Porcelaine Enameled Sanitary Ware Catalogue F.* Port Hope, ON.
This large catalogue includes extensive diagrams and pictures of the wide range of plumbing fixtures offered by this Canadian company. 923 plates.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

13.2

PERIOD SERVICING

HEATING AND VENTILATION

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

The purpose of this article is to provide an historical overview of period heating and ventilation systems. Such a study is important for several reasons. Current standards of acceptable heating levels are based upon recent technology and access to a wide range of fuel sources.

This article will endeavour to put period heating and ventilation technology into its proper perspective and thereby serve as a guide for the restoration of period systems, as well as any innovative adaptation or appropriate intervention required to achieve the goals of a period restoration and modern comfort levels. While most systems are the inventions of other countries, particular attention will be paid to the various elements in their Canadian context. This article is a companion to Vol. III.6.2 "Period Heating and Ventilating."

2.0 HEATING SYSTEMS

Early humans derived fire from natural resources, by friction of wood, percussion of rocks or by optical methods. Fire formed the nucleus of human groupings. Attempts to preserve and contain it and the heat it produced influenced the development of the built form. Once fire was contained within the primitive shelter, three problems immediately became evident: ventilation of the smoke and gases, control of draughts and the lack of even distribution of heat. Appropriate fixtures, fuel sources and ignition systems were slow to evolve. For example, a safe "match" was not in common use in Canada until the mid-19th century.

Ancient civilizations like those of Babylon, Rome and China achieved a high degree of sophistication in their heating systems. The Roman system, for example, was to provide in a hollow space beneath tile floors, air heated by a fire at one end of the space which was directed around a series of 450 mm (18 in.) columns which heated the floor above.

Some of the renowned Roman baths had capacities in excess of 3000 people. Unfortunately all this technology was lost to the world after the final sack of Rome in 455 AD. Thereafter the process of evolution was painfully slow.

Early Canadian heating systems were almost exclusively developed in Europe or the United States. Indeed, despite significant coal deposits, no attempt was made to develop a heating technology specific to the particular characteristics of the Canadian grade of coal. Neither did our country's temperature extremes result in any more rapid development of technological advances.

2.1 FIREPLACES

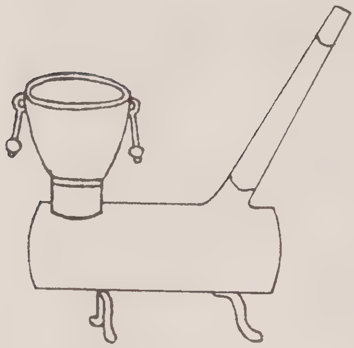
The progression from open fire to the early fireplace took several centuries and was based upon the search for a system that would ventilate the vast quantities of smoke generated. Gradually, the fire was moved from the centre of the room to a side wall under an arch; the ventilation hole was at the top of this sloping arch. During the reign of Henry III (1227-72), ceiling louvres were used to vent the smoke and a variety of hoods in wood or plaster were developed to collect the smoke.

It is not known who invented the chimney as we know it. The oldest remains found in England date from 12th century Kenilworth and Conway Castles. The earliest written records concerning chimneys date from 1347 descriptions of an earthquake in Venice that year. By Tudor times, chimneys had become prominent architectural features and a great deal of attention was paid to decorative details. In 1624, Louis Savot of France introduced the raised hearth and reduced the width and height of the fireplace. The next innovation was the baffle system created for Prince Rupert by an English bricklayer, Bingham. This reduced the flow of air from the room up the chimney and redirected the smoke back toward the fire before it was expelled.

The "furnus acapnos," a circular iron bowl resembling a clay pipe, was invented in 1682 by Dalesme and exhibited at the Fair of St. Germaine in Paris that same year. It too redirected the smoke, causing it to pass through the burning fuel before venting.

In the early 18th century, Nicholas Gager expanded upon Savot's principles in *La méchanique du feu*. This work was translated into English in 1716 by the Reverend J.T. Desaguliers. Despite the passage of over 12 centuries, only 20 percent of the heat generated by heating systems was actually being distributed within the room.

The hearth has always been the focal point of domestic buildings. The chimney, its exterior expression, has dominated residential and industrial skylines. Inside homes, the fireplace, the mantlepiece and the surrounding casing continue to embellish rooms even though they may not be required for heat or may be false decorative elements.



"FURNUS ACAPNOS"

A "smokeless stove" invented by Dalesme and exhibited at the fair of St. Germaine in Paris, 1682 (Pierce).

In early Canadian building, while the fireplace may have been stone or brick, chimneys were often constructed of clay and straw spread over a ladderwork which was attached to a wood frame. This wood frame consisted of four poles and the ladderwork was secured to the frame by clay "cats." Variations on this model were used throughout Canada. These chimneys posed a serious fire hazard and were soon legislated out of existence in urban areas in favour of stone or brick.

The backplates or "contre-feu" of early French fireplaces were often decorated, not by ceramics as in 15th century Europe, but by iron. These plates reflected heat back into the room. Grille work was usually installed to prevent fire logs from damaging the decorations. In New France, the designs depicted religious themes and sometimes the arms of France. They were produced at forges at Saint-Maurice and Trois-Rivières.

The mantlepiece soon became the primary focus of the fireplace's decorative features. Mantles reflected the economic status and often the ethnic origins of the homeowner. As such they are an interesting source of information for those working on period restorations. Indeed, the size and number of entire fireplace units is an important indicator of the social status of the original occupants.

Early mantles were little more than stone ledges, but they soon evolved into wide wooden shelves often carved by skilled craftsmen. At the beginning of the 19th century, they were influenced by neo-classical designs from New England as well as the very popular British designs of Robert Adam. In mid-Victorian times, wood was replaced by marble which reflected the increasing affluence of the growing population.

Fireplaces with exterior grilles were also found in Upper Canada and English settlements in Lower Canada in the late 18th century. Small grille baskets were hung from the side panels at a level above the hearth. This style became popular again later in the 19th century when they were used to provide more ambiance than heat to the Victorian parlour.

By the turn of the 20th century, wood regained its predominance and oak-stained mantlepieces were popular. An additional feature was the overmantle, sometimes containing a mirror, which dressed almost the entire space between floor and ceiling in Beaux-arts or even Art Deco stylings.

2.2 BRAZIERS

Braziers have been used as a heat source from early times. In New France, they appear to have been used as the primary source of heat for large public buildings such as churches. This seems to follow a general European tradition. As late as the late 18th century the House of Commons (Westminster) was heated in this fashion. Little is known about their domestic use.

2.3 STOVES

Early stoves probably evolved from the brazier and the brick heating stove. They are known to have been used by the Romans and Chinese. Stoves were made of brick, tile and soapstone in addition to cast iron. Cast-iron stoves, slow to develop, appeared for the first time in Europe, in Alsace, around 1475. This method of heating spread throughout Europe, but it was retarded by several centuries in England, perhaps due to a kinder climate.

The Carron Iron Works of Stirlingshire, Scotland, was producing stoves in 1759 and importing them to the Americas. However, stoves were already in use in the American colonies, where their production was influenced by pilgrim settlers who had spent years in exile in Holland prior to setting out for the new world. By 1646, the colonies were producing enough iron for export purposes.

The evolution of the stove followed lines similar to the development of the fireplace. The problems were the same: how to achieve efficient burning and control "that greatest of all plagues, a smokey chimney." Benjamin Franklin developed a cast iron "fireplace" in 1745 which gained much respect. Variations on the theme and scheme for circulating smoke and containing heat as long as possible continued to be invented.

A cast-iron Franklin inset placed in a larger fireplace opening, 1780 (Hutchins).

The Franklin reflector, fire frames, box stoves and brick renditions, which held the heat longer and had no iron smell, came into use. Stove pipes were introduced to conduct the warm air throughout the house. Even in 1884, "Professor Espy's Patent Smoke Blowers, a Sure Cure for Smokey Chimneys" found a ready market in Boston. Stove pipes also presented certain hazards and flue ventilators were devised to allow the safe passage of the tin pipes through floors and walls.

No major innovation took place until double vertical flues, connected by a horizontal pipe from which another pipe led to the chimney, were introduced in the mid-19th century.

The first air-tight stove was invented by an American, Isaac Orr, in 1836. This oval-shaped apparatus marked the first real change in the shape of stoves for many years.

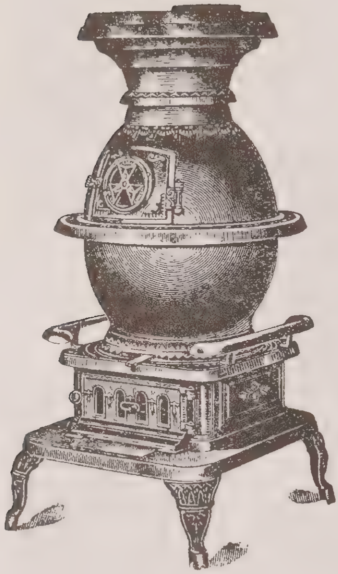
Improved stoves resulted in a delivery rate of 70 to 80 percent of the heat in the fuel – from the standpoint of economy they were a success. However the radiant heat provided was not completely successful in providing a comfortable environment. Separate units for each room were required.

The first stoves used in Canada were European either in design or origin. Many were brought out with early settlers. During the French régime, they were manufactured at the forge at Saint-Maurice, PQ, shortly after the conquest. In 1762, stoves were produced which substituted the British arms for the French.

After the late 1770s, large numbers of stoves produced at the Carron Foundry in Scotland began to appear in Canada well into the 19th century. The French Canadian models were less popular than their British counterparts because they were too large, cracked easily and the fire was not visible. The latter was considered a highly desirable feature of English models.

While relatively few stove types were available prior to the 1830s, numerous models were marketed after that date. This was particularly the case after 1840 when coal-burning models were available. Nine general classes of stove could be purchased.

Marcel Mousette listed 123 foundries in 61 districts in Upper Canada before Confederation. As well, there were many small foundries in Quebec. However, despite these foundries, stoves continued to be imported in large volumes.



(Sears, Roebuck Catalogue, *1908*)

2.4 AIR-TIGHT STOVES

Invented in 1836 in the United States, air-tight stoves appeared in Canada in the 1840s. They were prized for their slow combustion rate and heat retention qualities. Constructed of sheet metal, they were usually oval-shaped – although the box-shaped "Polar Air Tight" model was manufactured in Lanark, ON, in 1855 by James Dobbie.

Canadian versions included the *Air Tight Six Plate* by the Crown firm of Kingston, ON, the *Brockville Air Tight* by the Colton Company of Brockville, ON, and the *Lion Tamer Air Tight* and the *Vulcan Air Tight* by the Phoenix factory of Toronto, ON.

In Lower Canada models were made by the Ross family at La Fonderie de la Canoterie of Québec and the Rodden family at the City Foundry in Montréal.

2.5 WARM AIR FURNACES

As buildings increased in height, carrying wood or coal up and down to numerous fireplaces or stoves became very inconvenient and ventilation concerns became more complex.

The introduction of the warm air furnace brought about significant changes in lifestyle which were reflected in the design and use of interior space. This was because it was no longer necessary to place the heating unit in the living-working space. As well, the unpleasant metallic odour of cast iron stoves was removed from these areas.

The warm air furnace was a natural outgrowth of the stove. It consisted of a firepot and an extended flue surrounded by sheet metal casing. Air flowing through the casing was warmed and directed through pipes to registers in various locations. Humidification was provided by the addition of a pan of water above the dome. Fans were later added to increase the efficiency of this system. These furnaces could be fired with gas or by mechanically introduced coal or oil.

Warm air systems were the most popular of all early heating systems in late-19th-century urban Canada. Air heated much faster than water and it could be circulated in ducts concealed behind walls and under floors. The first systems appeared in the 1820s and in 1841 an enormous system was designed for the government buildings in Toronto. This system featured flat-sided pipes which increased the efficiency of the unit by increasing the surface of the metal heated.

Two types of warm air systems were used. The first was a small unit which consisted of a small stove encased in brick or metal which would be located in one room. A system of pipes transferred the heat to other rooms.

The second type was more appropriate to larger homes and public buildings. This furnace was large and therefore located in the basement. Air brought in from the outside to a brick chamber was heated and circulated throughout the structure through ducts and radiators.

Thermostats, introduced to take advantage of the various valves and dampers on furnaces, were designed to control temperatures. A thermostat could be conveniently installed anywhere so that drafts and dampers could easily be adjusted to the required temperature. By the early 20th century they could be connected to a clock to regulate the appropriate adjustments.

2.6 STEAM HEATING SYSTEMS

The prototype of the steam heating system was invented in England in 1745 by Cook. This device could heat eight rooms spread over three floors.

Nineteenth century models included, in addition to the fire chamber, a boiler to generate steam which was distributed throughout the structure by means of pipes and radiators. The initial one-pipe system utilized the same pipe to disperse the steam as well as return the water, caused by condensation, to the boiler. This system proved to be noisy and had an unpleasant odour. Its efficiency was limited because pressures were difficult to control and the radiator valves had to be either on or off. The two-pipe system was developed to overcome these problems.

It would appear that the first steam heating systems in Canada were introduced in 1815 by Wisly and Moore of Montréal. However, the system did not achieve much attention until 1857. Although they were produced at foundries like the City Foundry in Montréal, they were not widely used. Steam heating systems were more popular for commercial and industrial uses than domestic, in part because of the dangers of circulating steam under pressure.

2.7 HOT WATER SYSTEMS

Hot water systems were known in Europe from the late 1770s. Water instead of steam was circulated by gravity or a pump through a structure by means of pipes and radiators. An expansion tank, usually located at the top of the circuit, accommodated the changing water volumes resulting from fluctuating temperatures.

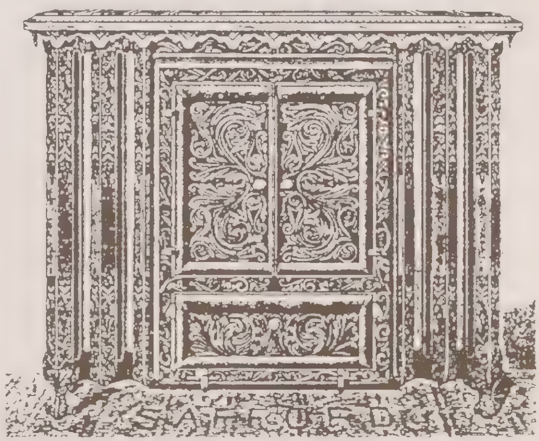
The hot water system had several significant advantages over steam; the chief among them was efficiency. By controlling the pressure in the boiler, water temperatures could be increased to 240°F without boiling and the size of the radiators could be reduced. Therefore, it responded quickly on demand and retained the heat longer in the system. Furthermore, the radiators could be adjusted to provide a wide range of heat levels. Fuel consumption was considerably reduced.

Although hot water heating systems were known in Europe since 1777, they do not appear to have been manufactured in Canada until the late 1850s. At that time they were introduced for sale by a Montréal manufacturer. They were considered a great improvement over hot air systems because they allowed more control over a wider range of temperatures and they kept coal dust and fumes from circulating up from the heating unit in the basement.

2.8 RADIATORS

Radiators are an important component of steam and hot water heating systems. They could be constructed of wrought or cast iron, brass or copper, pressed steel or pipe coils in a one-pipe or a two-pipe configuration. One-pipe systems (steam) joined the sections at the bottom while in two-pipe systems (steam or hot water) sections were connected both at the bottom and the top.

Cast iron was a popular material because it was purported to give off 18 to 25 percent more heat than wrought iron. The Toronto Radiator Manufacturing Company produced the "Safford" line of radiators in this material. Its catalogue promoted the larger number of ornamental designs made possible by its special properties. They also marketed the valves and joints which made the radiator's operation so successful. The list of endorsements contained in the 1893-94 catalogue demonstrated that the company's products were used across Canada – served by branches in Saint John, Montréal, Quebec City, Winnipeg, and Victoria.



(*Safford Radiator* Catalogue B, *1893-94*)

While there was general rejoicing when the heating apparatus was moved out of the living room and into the basement, there was little resistance to the installation of radiators despite the problems they caused in placing furniture. In true Victorian spirit, radiators became part of the decor. After the turn of the century, when there was a trend to reducing their size, hanging these narrower versions on the walls and finally concealing them in the walls or in metal box casings was common.

2.9 CENTRAL OR DISTRICT HEATING SYSTEMS

Central (or perhaps to use a more descriptive term, district) heating distribution systems have not been used extensively in Canada. Prior to the Second World War they could be found in Montréal, Ottawa, Winnipeg, Brandon, MB, North Battleford, SK, and Vancouver. Excessively low temperatures and low-grade coals were major factors in the reduced popularity of this system. However, in 1916 North Battleford was using exhaust steam from its power plant for district heating. In the 1920s, the Cliff Street Central Heating Plant in Ottawa initiated the distribution of steam heat. This extends from the Supreme Court to the Parliament Buildings and on to the new National Gallery of Canada.

3.0 FUELS

The availability of different types of fuel played a significant role in the evolution of heating systems. By the turn of the 20th century, heating technology still revolved around the traditional fuels – wood and coal – which did little to bring about dramatic innovations or rapid change.

3.1 WOOD

Wood was one of the first materials used to produce heat. In Canada, early settlers found no shortage of this fuel. In fact, wood continues to play a major role, especially in rural areas. Its use was occasionally supplanted by coal in urban areas where coal could be provided more cheaply; however, coal-burning stoves were not available before the mid-19th century.

3.2 PEAT

Dried "bricks" of peat turf were a common heating fuel in many European countries. This method was rarely used in Canada because of the abundance of easily accessible wood as well as the availability of "ready to use" coal. However, early mention is made of its use during exploration of the north coast of the St. Lawrence River in 1743.

3.3 CHARCOAL

The use of charcoal has been identified from as early as the Bronze Age, primarily for industrial purposes. With limited exceptions, such as use in portable braziers, its use in Canada continued along similar avenues. It is known to have been used in the forges and foundries of both Upper and Lower Canada. Early 17th-century records reveal that it was used at the forge at Port Royal and in the forge at the mission in Detroit in 1736.

3.4 COAL

Coal has been known from the earliest historical times. It figured in a treatise by Theophrastus in 371 BC. The first recorded use in Great Britain was documented in the records of the Abbey of Peterborough in AD 852. In 1239 the King granted a charter to the people of Newcastle to dig for coal. While there is a wide range of coal types, it can be divided into soft bituminous coal and extremely hard anthracite coal. The softer coals produced very black smoke and soot and while easier to ignite, they were not popular in London until the late 17th century because of the fumes and dirt. The soot also affected the degree of ornamentation in a room, because of the difficulties in keeping it presentable.

Coal initially was burned with wood until an iron cradle or cage was invented to hold the coals. While early stoves were not made to handle coal, they were often adapted to serve this purpose. Coal proved to be a versatile and inexpensive fuel source. Although, just as the control of oil supplies has created havoc in modern times, coal shipments of earlier times were often blockaded.

It is interesting to note that as early as 1594, Sir Hugh Platt, after inventing a smaller version of the fireplace, also developed a conveniently sized fuel. This fuel was shaped into balls comprised of coal dust and loam.

Anthracite coal is extremely hard. Although it offered the benefit of little smoke, it was expensive and difficult to ignite. It was first burned in a grate in Philadelphia in 1802, but the first stove especially made for burning anthracite coal was not cast until 1820 (Mary Ann Furnace, Bucks Co., PA.). This was known as the Lehigh coal stove.

Early Canadian settlers found abundant supplies of wood and therefore had relatively little need to exploit coal resources. Coal was first mined in 1639 in New Brunswick and by 1720 French soldiers were tapping the rich Cape Breton sources to provide fuel for the fortress at Louisbourg. In western Canada the need to fuel coastal supply steamboats precipitated the opening in 1836 of the first coal mine on Vancouver Island. After 1911, most Canadian coal was produced in the western provinces.

Despite the early identification of Canadian sources, coal was rarely used in French Canada before the arrival of the British and then its use was largely due to the expense of wood in some areas. Even under those circumstances the Canadian product was passed over, except for industrial use, in favour of competitively priced English coal brought over as ballast. In Upper Canada, coal was imported from Ohio via the Welland Canal after 1841.

Coal-burning stoves were readily available from the 1840s onward, but they were first used only by the urban English, the more prosperous English and French households, or where it was less expensive than wood. Wood continued to be the primary fuel for fireplaces and in rural areas until the mid-20th century.

The availability of another fuel source (wood), the cleaner burning and better quality of imported coal and the relatively sophisticated technologies brought over by early settlers from their own homelands, perhaps help to explain why Canadians failed to develop heating technology to accommodate the generally lower grade Canadian coals. Coal continues to be used for industrial purposes.

3.5 COAL GASIFICATION

The process of converting coal to a fuel gas was developed around 1780 and was in wide use by the early 20th century both as a lighting fuel and as a heating fuel.

The first Canadian use of gas for heating appears to have been for an invention of Samuel Cutter of Montréal in 1854:

> It is the method of procuring artificial light and heat by forcing atmospheric air through a mixture of water, alcohol, benzole, or other hydro carbon, the same air having been previously rendered damp by being forced through a bath of pure water (Mousette, p. 182).

Gas stoves by Robert Rogers and Charles W. Barry, both of Montréal, were available in 1866 and 1867 respectively.

3.6 KEROSENE

Kerosene was first distilled in 1846 by a Nova Scotia native, Dr. Abraham Gesner (1797-1864). Gesner developed this process for distilling kerosene from a coal-like substance now known as albertise. He then moved from Nova Scotia to the United States where he applied for a patent in 1853. In 1854, he established the North American Kerosene Gas Light Company on Long Island. Originally used to produce light, it was not until 1864 that kerosene was considered for heating purposes, when John Hart of Granby County applied for a patent. Further refinements in heating apparatus were reflected in the patents secured in 1867 by Homer Taylor of Montréal and F. Cook of Oil Springs, ON.

3.7 FUEL OIL

Heating systems benefited from the advent of the automobile. Fuel oil was an inexpensive by-product of the petroleum refining industry which was trying to meet rising demands for gasoline. This product gradually replaced coal both in industry and home heating.

4.0 VENTILATING SYSTEMS

Ventilating concerns are an important element in the comfort and livability levels of any structure and a critical factor in an efficient heating system. In period restorations, ventilating systems are a particularly sensitive matter, especially where modern heating standards are required. Similarly, original air conditioning functions demand careful attention before any new system is imposed upon a period restoration project. Old buildings often have inherent thermal properties, such as heavy masonry walls, skylights or fan systems which require little improvement.

4.1 VENTILATION

The process of ventilation involves a system which will regulate the inflow of fresh air and the expulsion of contaminated or "vitiated" air within a structure so that an even, desirable temperature is achieved. In early days, air contamination meant smoke. To eliminate the smoke generated by inefficient heating systems, windows or doors were opened. Later, baffle and damper systems were added to chimneys in an attempt to control both the exit of the smoke and the accompanying draughts. As heating systems became more sophisticated, self-regulating drafts and fans were added to gravity heating systems to increase the flow of air and provide better control over the environment.

The main impetus for improved ventilation technology arose out of the Pure Air Movement of the 19th century, an early environmental interest group. The fear of tainted air resulted in more rapid technical developments than centuries of un-

comfortably cold homes. The ventilation system developed for the United States Capitol Building became a model for proponents of the need for proper exchange of air for maintaining good health.

4.2 AIR CONDITIONING

As with heating and ventilation systems, air conditioning systems were developed outside Canada, primarily in the United States. Machines for making ice on a large scale were introduced in 1851 in America and this spurred the development of air cooling systems. As well, hot water heating systems could be adapted to circulate cold water in the warm months.

The advent of electricity and more sophisticated refrigeration techniques resulted in the first true air-conditioning unit in 1902. The concept originally was intended for industrial use, but some residential units appeared after 1914. Because of the high cost, however, it was not until the 1950s that individual units were suitably priced for the domestic market.

In the Canadian context, the Orpheum Theatre, Vancouver (1927), is an interesting example of an air conditioning unit designed for large public spaces. Its system consisted of ice coils and cooled water supported by two generators capable of producing 250 tonnes of ice every 24 hours. A complete change of air in the theatre took place every seven minutes or so.

5.0 CONCLUSION

Three of the earliest sources of heat utilized by humankind – the sun, the human body and fire – remain critical elements in any study of the development of heating and ventilation systems. Indeed in some respects it might be argued that we have come full circle.

With the possible exception of plumbing systems, heating appears to be one of the last comforts to receive attention, despite the intemperate climate of much of the world. The major innovations in the field have been confined to the last 160 years and – in terms of turnover of new ideas – to the last 50 years.

It took several centuries for the hot water bottle to evolve from the heated brick and yet another century before the invention of the "hot shot," which in itself is a useful addition to the potential restorer's kit.

6.0 BIBLIOGRAPHY

Arnott, Neil. 1855. *On the Smokeless Fireplace, Chimney Values, and Other Means, Old and New of Obtaining Healthful Warmth and Ventilation.* Longman, Brown, Green and Longman, London.
This book, which presents an in-depth discussion of heating methods during the 19th century, provides a very useful overview of warming buildings with fires, heat transfer systems and stoves. Excellent line drawings and other illustrations.

Couillard, Daniel, and René Bouige. 1972. *Chauffage, Ventilation, Climatisation.* 2nd ed. Editions Eyrolles, Paris.
A technical manual on heating and ventilating techniques; primarily those used in France during the 20th century.

Heating Engineers Companion. 1908-9. Gurney-Oxford, Toronto.
A catalogue of the Gurney Foundry which manufactured radiators, boilers and water heaters. The company sold its products through offices in Toronto, Montréal, Hamilton, Winnipeg, Calgary, Edmonton and Vancouver. Well illustrated.

Hill, George. 1895. "The Heating of Buildings," *Architectural Record,* Vol 5 (October-December), pp. 204-11. New York.
This article considers the methods of heating and ventilation most appropriate for public and private buildings of various sizes.

Hood, Charles. 1869. *A Practical Treatise on Warming Buildings by Hot Water, Steam, and Hot Air On Ventilation and the Various Methods of Distributing Artificial Heat, and their Effects on Animal and Vegetable Physiology.* 4th edition. Whittaker and Co., London.
This book provides an easily read overview of the field from historic times and a detailed description of the various apparatus used in heating and ventilation systems. The text also provides an interesting insight into the social philosophy which inspired their invention. Illustrated.

Kidder, Frank E., and Harry Parker. 1936. *Kidder-Parker Architects' and Builders' Handbook Data for Architects, Structural Engineers, Contractors and Draftsmen.* "Heating and Ventilation of Buildings," Chapter XXX, Louis A. Harding. 18th edition. John Wiley and Sons, Inc., New York, pp. 1561-1693.
This book, which was first published in 1884, provides a comprehensive description of heating and ventilating systems along with numerous charts and illustrations.

Konzo, S., and R. W. Roose. 1947. "Recent Developments in Residence Heating," *Architectural Record,* Vol. 102 (November), pp. 121-25.
This article deals with advances in residential heating systems to 1947 and includes an outline of problems faced in conventional buildings with and without basements. Controls for solar-heated homes are also considered. The article has several useful diagrams.

Mousette, Marcel. 1983. *Le chauffage domestique au Canada, des origines de l'industrialisation.* Ethnologie de l'amérique française. Les presses de l'Université Laval, Québec.
This excellent book provides a well-illustrated, detailed study of heating systems in pre-confederation Canada. However, the binding is very poor and the volume is therefore handled with great difficulty.

__________. 1972. *Répertoire des fabricants d'appareils de chauffage du Québec (1760-1867), Répertoire des fabricants d'appareils de chauffage de l'Ontario jusqu'a 1867. Les appareils de chauffage importé au Québec et en Ontario jusqu'en 1867.* Manuscript on file. Parks Canada, Ottawa.
Material assembled for the volume preceding is put forward in easy to read format. This unedited edition contains more diagrams and photographs.

Page, Forsey. 1946. "Heating," *Journal of the Royal Architectural Institute of Canada* (January), pp. 3-5, 19.
This article considers the advantages and disadvantages of central or district heating plants. It also looks briefly at the possibilities for heating with electricity, an expensive proposition at that date. Ventilation is also looked at in very brief terms.

Pierce, Josephine H. 1951. *Fire on the Hearth The Evolution of the Heating Stove.* The Pond-Ekberg Company, Springfield, MA.
This book provides a brief history of fire and its uses as well as a comprehensive guide to the development of stoves, primarily in America. A valuable patent list of stoves is included, along with a list of early stoves in America, their type, location and date. Illustrated.

Safford Radiators. 1893-94. *Catalogue B.* The Toronto Radiator Mfg. Co. Ltd., Toronto.
An excellent period catalogue with illustrations and accompanying text on the various heating systems in use at the end of the 19th century. Includes 131 photographs or drawings of buildings (exteriors) which contain Safford equipment and 15 pages of references from private, public, and commercial clients across Canada.

Smead, Isaac D. 1899.*Ventilation and Warming of Buildings.* Smead and Northcott, Elmira, NY.
An interesting treatise on the philosophy and apparatus used in heating and ventilating buildings with specific reference to the 13 patents held by Smead. The book contains interesting illustrations, some of which are coloured.

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

13.3

PERIOD SERVICING

LIGHTING

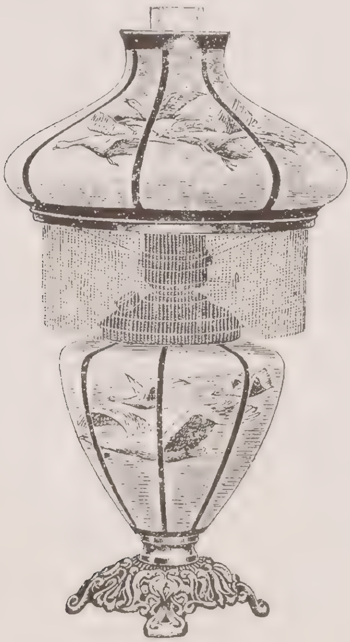
PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

The use of appropriate lighting, light fixtures and lighting systems is an important part of any period restoration. To recreate the ambience of a particular space requires not only a knowledge of systems and their technology, but also a general understanding of the era in which they were used. The development of lighting in Canada is therefore linked to technological as well as to stylistic changes. American and European lighting developments influenced Canadian trends particularly when new settlers arrived in this country and communications increased with other parts of the world.



Lamp (Sears, Roebuck Catalogue, *1908)*

Although much has been written about lighting in the United States and western Europe, it has only been in the last few years that there has been an interest in early Canadian lighting techniques. A general interest in history and technology has contributed to this growth and the recent popularity of antique furnishings has created more interest in older lighting fixtures. Copies of period fixtures are now widely available and their use is common not only in period restorations, but in many older buildings as well.

The purpose of this article is to provide an historical overview of lighting with a particular emphasis on the Canadian context. In many cases lighting techniques and specific lighting systems were developed in the United States and then brought to Canada where they remained largely unchanged. Others were adapted to suit particular needs in this country. Both kinds are discussed in this manual.

2.0 TYPES OF LIGHTING SYSTEMS

2.1 HISTORICAL OVERVIEW

Artificial lighting can be traced to prehistoric times when humankind began to make fires and light torches. Wood-burning fires served as both light and heat sources. Gradually, crude stone or pottery lamps were developed. Archaeological excavations in the Middle East and Europe have revealed that about 20 000 years ago sandstone lamps were used in France. At the end of the Bronze Age, 10 000 years ago, oil lamps were used by lake dwellers in Switzerland. During the expansion of the Roman Empire, oil-burning pottery lamps, made from either sun-dried or baked clay, were transported throughout the Mediterranean and north to Gaul and Britain. Bronze lamps for the upper classes which were popular in both Greece and Rome, carried on through the ages. Wooden torches, crude candles and clay lamps continued to be used throughout the Middle Ages. Grease-burning lamps which were, in essence, metal versions of stone lamps used by cave men, were popular in the Middle Ages as well. For centuries the Inuit used similar whale-oil stone lamps.

Wick-support lamps appeared about 1400. Float lamps with wicks either floating on the oil's surface or attached with wires have existed since the time of King Tutankhamen. Later, scholars and artists frequently referred to these lamps. They were the "eternal lights" in temples and churches. Into the 18th, 19th and 20th centuries, float lamps continued to be used despite an abundance of new inventions and more sophisticated lighting techniques.

Another type of light which has stood the test of time – from the late Middle Ages in Central Europe to 1850 in the United States – is the Betty lamp. This lamp was a usually pear-shaped wick-support lamp with a cover and a vertical handle so that it could be either hand-held or hung up.

Candles continued to be an important light source both in Europe and in North America from the time of the earliest European settlements. Candles were made of tallow, either formed in a mould or dipped by hand. This composition and process continued until paraffin was introduced in the 1860s. Today candles are still an important light source, particularly as a decorative addition in domestic settings. As styles changed so did the design of candle holders and by the 19th century many elaborate designs were popular.

The late 18th century was the era of invention in the history of lighting. The most significant invention was the centre-draft burner designed by a Swiss scientist, Ami Argand, in the 1780s. Other types of lamp fixtures were developed for new fuels including burning-fluid, kerosene and acetylene as well as old fuels, such as lard and whale oil. Glass and brass were frequently used for these new fixtures and a wide variety of designs soon became popular for domestic use. New techniques to create brighter, odourless and safe lighting were developed over the succeeding century. Gradually, efficient and inexpensive fixtures combined with new fuels enabled both urban and rural homes to have sufficient illumination.

Gas lighting, introduced to Canada in the 19th century, required an elaborate installation and distribution system and was therefore available only in urban areas. Public buildings – and residences for the more affluent – were lit with gas in the first half of the 19th century. Concurrently, gas street-lighting appeared in Toronto, Montréal, and Quebec City, in the 1830s and 1840s. This brought about important changes in these cities and created a new demand for light fixtures both inside and outside the home.

With the introduction of electric lighting and Thomas Edison's incandescent light bulb in 1879, lighting in North America changed dramatically. Gradually gas and oil-burning lamps were replaced by electric lamps. This occurred more rapidly in urban areas though many residents in rural areas continued to depend on kerosene lamps into the 1920s.

International expositions such as the 1878 Paris World Fair and the Columbian Exposition in Chicago in 1893 introduced new exterior lighting techniques to a wide public audience and created an interest in exterior illumination. This interest quickly spread throughout Europe and North America. Merchants were instantly attracted to exterior lighting for their storefronts and this created a new demand for signage and light fixtures. Domestic buildings were also lit on the exterior which created a new look in cities. The most popular system was the arc lamp which was used extensively between the 1870s and the 1950s, when high-intensity incandescent lamps became popular. Gas lighting was gradually phased out as electric lighting became more sophisticated by the beginning of the 20th century.

Stylistic changes and fashion influenced lighting over the centuries. Each era fostered not only technological advances but also changes to the design and decoration of fixtures. Simple austere holders were replaced by ornate and intricate chandeliers during the 19th century. The image of each era became clearly visible in its style of fixtures. Thus the evolution of early lighting systems represents both technological as well as stylistic changes characteristic of each time period. The decorative arts and lighting reflected the architectural trends, particularly during the 19th century, when, for example, Gothic Revival and Queen Anne designs were prevalent.

Art Nouveau Decorative Ironwork (Menton)

This tradition carried on into this century. It is clearly visible in Tiffany lamps, unmistakably characteristic of Art Nouveau, and later on, Art Deco fixtures, which reinforced the geometric and clean lines of 1930s architecture.

2.2 OIL LAMPS

One of the most long-lived and versatile kinds of lighting is the oil lamp. Variations of these lamps have been used for thousands of years, ever since animal or vegetable fats were first placed in shallow stone dishes and fibres used as wicks. Gradually the lamps became more sophisticated. Olive oil and cotton wicks in pottery lamps were used in Mediterranean countries. Northern European countries, which did not have olive oil, used solid fuels in a wrought-iron lamp. A simple oval shape with a narrow area for the wick was the basic form of these lamps. The Crusie lamp, used in colonial times in the United States and in eastern Canada, was similar to that from the Scottish Highlands. Here in Canada, the most common fuel was a piece of fat which turned into oil as the flame burned.

A variation of the Crusie lamp was the Betty lamp. It has been suggested that the name derives from the German *besser* or better. These lamps had a number of notable improvements including a separate wick trough so the wick would not fall into the fuel cavity. They also had a cover. They were brought to Canada by settlers from Pennsylvania following the American Revolution. They were widely used in the 18th and early 19th centuries; however, their popularity had declined before the invention of kerosene lamps.

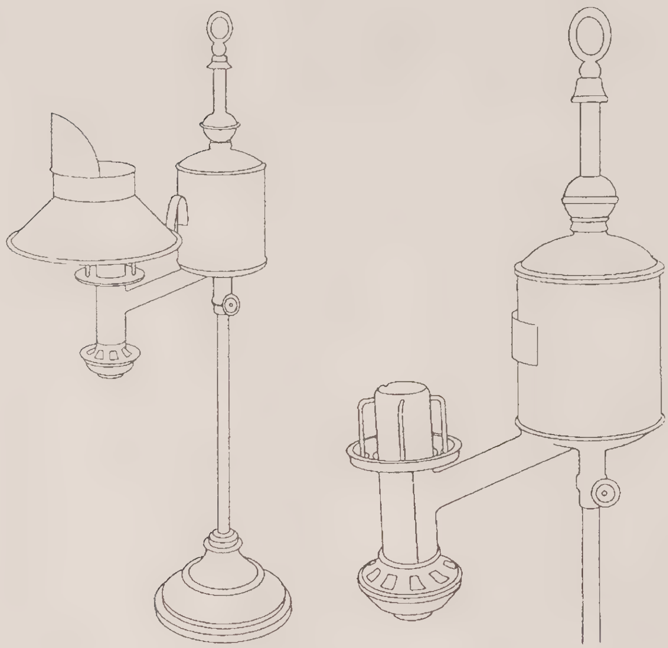
Whale-oil lamps made of glass, tin and brass were very popular in the new colonies, as they were in northern Europe where whale oil was a source of fuel when olive oil was not available. During the early 19th century the whaling business boomed off the east coast of both the United States and Canada. Whale oil served as a lighting fuel as well as a lubricant; however, the supply of whales decreased and as a consequence the cost of the oil rose and other types of lamp fuels were developed. Along with the quest to find an odourless, efficient, safe and economical fuel, came the desire for new lighting devices which would brightly illuminate interiors. A series of inventions ensued and great strides were made in the late 18th and early 19th centuries which revolutionized modern lighting techniques.

The Argand lamp, invented by Ami Argand, a Swiss physicist, revolutionized lighting around the world. Argand is credited as being the father of scientific lighting. Although he did not receive encouragement in France where he tried to patent his invention, he succeeded in doing so in London in 1784. This significant invention began the development of modern illumination.

The characteristic element of the Argand lamps was the centre-draft burner with a tabular wick held between two metal tubes, the inner one open at the bottom to permit air to enter. This created a draft which significantly increased the level of illumination. The flow of fuel (vegetable or whale oil) was supplied from a reservoir to the burner via a horizontal tube. Other inventors carried on Argand's work and developed more sophisticated versions including the Astral, Solar, Mantel-Arm, and Carcel lamps as well as the Rochester Burner. The design of the lamp itself was modified to reduce shadows cast by the reservoirs, to control the flow of oil and to produce a brighter light source.

The most important innovation which followed was the development of an efficient and inexpensive fuel. As the price of whale oil increased in the 1850s, a new fuel composed of high-proof alcohol and redistilled turpentine became popular. Known as burning fluid, it had the advantage of emitting a white smokeless flame. It was highly flammable. Burning fluid was patented in 1830 in New York City by Isaiah Jennings who had also patented an improved Argand lamp the year before. A Canadian patent for burning fluid was issued to John Ratcliff of Odelltown, PQ. By the 1840s and 1850s burning fluid was widely available in Canada. It was inexpensive and readily available since it could be made at home and was very fluid. It became popular for a wide variety of glass and metal lamps.

During the same period, lard was also widely used. Although much safer than burning fluid, it was viscous and unless the lard was heated by the flame there was a problem with its flow up the wick. For the next twenty years numerous inventors developed lard lamps designed to overcome this difficulty. Many were produced in the United States and then imported to Canada.



Argand Lamp, ca. 1830 (Russell)

2.3 KEROSENE LIGHTING

A major breakthrough in the development of illumination in Canada was made in 1846 by Dr. Abraham Gesner (1797-1864). A Nova Scotia physician and geologist, Gesner was responsible for the invention of a new lamp fuel – kerosene – which was made from heated coal. The by-product of this process was a thin clear fluid which burned with a bright yellow flame. By 1855 kerosene was produced commercially and it grew rapidly in popularity since it was economical, safe and highly efficient.

Although Gesner had made his discovery while on a geological survey of Prince Edward Island, he was a native of Nova Scotia and spent most of his career working both as a medical doctor and later as a geologist in the province. He named his new fuel kerosene, derived from the Greek word *keroselaion*, which means wax-oil. Lacking sufficient funds to complete his work, Gesner moved to the United States and settled in New York where he and other businessmen established the North American Kerosene Gas Light Company. The new product grew in popularity and by 1857 kerosene was available in Montréal and Toronto and three years later in St. John's, NF. Gesner returned to Halifax in 1863 and obtained a Nova Scotia patent a year before his death in 1864. His invention had changed lighting techniques throughout North America and many new light fixtures developed as a result of this new product.

2.4 GAS LIGHTING

Although gas lighting was developed in England in the 1790s, it did not become popular until the early 1800s when major public improvements were undertaken. Street lamps, factories and public institutions were lit with gas far earlier than private homes. Likewise in the United States, experimentation with gas lighting occurred in the 1790s in Philadelphia and by 1816 the first commercial gas company

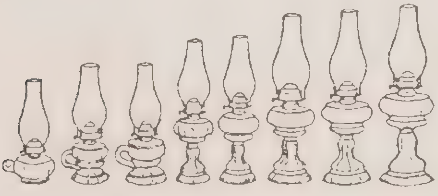
was established in Baltimore. Not until some fifty years later did gas lighting become popular for both domestic and commercial purposes in the United States and Canada. Until the First World War, gas lighting was widely used, particularly in urban centres. Its decline was due to the technological advances made in electricity.

Gas plants were located in neighbourhoods throughout a city. There coal was burned and reduced to coke. The resulting gas was then purified and distributed to individual buildings by means of a series of underground gas mains.

Within a building, the gas was distributed to individual rooms through a series of pipes which led to gas-lighting devices, either gasoliers or wall sconces. Since the furnaces and distribution systems were not located in the illuminated space, only the pipe leading to the light fixture was visible. Iron pipes or rubber hoses brought the gas to the fixture. Counterweights and pulleys made it possible to lower or raise the fixtures for purposes of illuminating and extinguishing the gasolier and a thumbscrew cock was used to turn the gas on and off.

Unlike preceding lighting systems, gas lighting permitted the overall illumination of a room, since the fixtures could be suspended overhead as well as placed along the walls. The light was much brighter and the central gasolier or chandelier provided a higher quality of lighting than lanterns, candles or oil chandeliers of previous eras. Because the fixtures were stationary, unlike kerosene lamps or candle holders, they could not be transported from room to room. Sometimes wall sconces had movable parts so they could be moved in front of mirrors for added illumination.

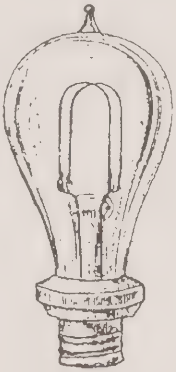
A wide range of fixtures, popular throughout the second half of the 19th century, ranged from simple inverted L or T pipes to much more ornate fixtures of cast metal and glass shades. Designed to match the interior decor, these fixtures were manufactured in styles which included the Rococo and Gothic Revivals, the "Eastlake" manner, as well as intricate floral and allegorical motifs.



From the T. Eaton Co. Limited Catalogue, *1899*

2.5 ELECTRIC LIGHTING

The development of electric lighting at the end of the 19th century radically changed illumination throughout North America. The first commercially viable incandescent light bulb was invented by Thomas Edison in 1879 in Menlo Park, NJ. The light bulb's basic design has not essentially changed over the past one hundred years, although electrical systems have improved significantly. Gradually, electric lighting became more efficient, light intensity increased, safety improved and techniques were developed to reduce shadows, glare and eye strain.



Lamp with double filament in the form of a cross, of sixteen candles.

Sixteen-candle lamp with double parallel filaments.

From Ferro and Cook

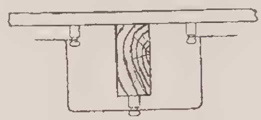
The earliest light bulbs of the 1880s were free-blown into a variety of shapes including globe-like forms, spherical balls, flames and a pear-like form which has remained popular today. Since the 1890s, glass bulbs were blown into moulds and their shapes became more standardized. Carbon filaments were originally used. With technological advances, these were improved with metallized carbon filaments. Subsequently the tungsten filament replaced the others in the first decade of the 20th century. Its intensity – almost ten times that of the original carbon filament – necessitated the design of new lighting fixtures to shield the intense light emitted by the bulb. Various methods to diffuse the light by frosting the exterior of the bulb were tried, including etching it with hydrofluoric acid, painting and sandblasting it. Not until 1925 was there a commercially practical method of frosting the interior of the bulb. In the interim, elaborate lamp shades and fixtures were used to reduce the glare while still lighting the room as brightly as possible. Concurrently, it became very fashionable to have decorative silk lamp shades, glass bowls and cast metal fixtures in both domestic and institutional settings.

The revolutionary development of the incandescent light bulb prompted accompanying developments in electric lighting as a system. There was an immediate demand for new products such as light bulbs, insulated wiring, wooden and porcelain cleats, wooden mouldings and decorative fixtures. When electric lighting was first introduced into a building, it had to be retrofitted to accommodate the new system. When this occurred, wires were often attached to walls and placed between floors in an unsafe manner. Makeshift wiring systems posed a serious threat of fire and therefore it was necessary to invent safer installation and distribution methods.

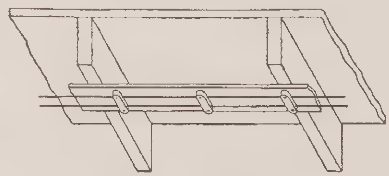
Wires needed to be insulated and attached to walls and mouldings in a safe and efficient manner. Various materials were used for insulating copper wires, including fibrous products such as woven fabrics, paper, felt and thread which were coated with oils and varnishes to reduce porosity. Synthetic resins and rubber replaced these other types of insulation towards the middle of the 20th century. The introduction of synthetic rubber, which was not sensitive to light and did not become brittle with age, was an important development for the insulation of electric wire.

Hand in hand with the development of appropriate and safe insulation materials were the methods of installation. This was particularly crucial when existing buildings were wired for electrical lighting. The earliest solution was to retrofit buildings with exposed wires attached to cleats on joists, walls, or ceilings or to attach the wires directly to the walls inside surface mouldings.

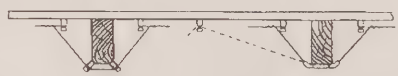
Wooden cleats were used for a short time at the end of the 19th century; however, due to fire hazards, porcelain cleats and knobs became popular and were much safer. This type of exposed wiring system remained in use for a long time. It is still used today for industrial and agricultural buildings, because it is much less expensive than concealed wiring.



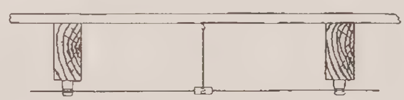
Method of Supporting a Small Conductor



Insulators Mounted on Running-Board across Wide-Spaced Beams



Method of Supporting Small Conductors



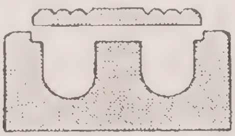
Intermediate Support for Conductors between Wide-Spaced Beams.

Cleats (Russell)

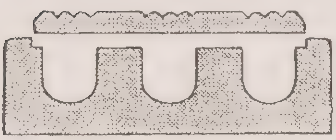
Although wiring concealed in wooden mouldings was not much safer than wooden cleats, it was aesthetically more desirable. It could be installed and altered with ease and could accommodate two or three wires. Metal moulding was also used to hide wiring systems. Its greater resistance to moisture and rodents made it more desirable than its wooden counterpart.

The "knob-and-tube" system of concealing wires between ceiling and floor joists could be installed easily beneath the floor finishes and was therefore widely used for retrofitted buildings. Code requirements regulated its installation and the use of rubber insulation. Since the wires were hidden within the building's wooden structure, rodents could gnaw at them or they could be accidentally damaged by carpentry work.

Rigid metal conduits, derived from gas lighting systems, were the natural successor for concealing wires within a building. Various materials were used – iron, steel and later armoured cables and plastic ones – throughout this century to conceal electric wiring and reduce the possibility of fires.

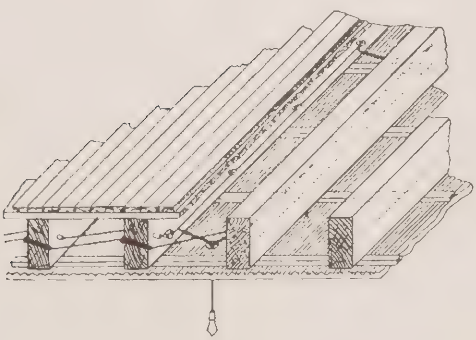


Two-Wire Moulding.



Three-Wire Moulding.

Mouldings (Russell)



Knob and Tube Wiring (Russell)

2.6 EXTERIOR LIGHTING

During the 19th century the most commonly used types of illumination for street lighting were oil-fueled lamps, carbon arc lamps, gas lights and electric lights. As technology developed, one method of lighting gradually replaced its predecessor. Not only did the quality and level of sophistication increase, but there was also a marked improvement in the quantity of decorative lighting on the exterior of buildings and along city streets.

Oil-Fuelled Lamps were used as street lights in Toronto, Montréal and Quebec City in the early part of the 19th century. These were fuelled with either animal or vegetable oil and kerosene. Although they did not produce a high intensity light, these oil-fuelled lamps served their purpose well.

Carbon Arc Lamps owe their origins to those lamps invented in 1810 by Sir Humphrey Davy, who is also credited with the invention of the miners' safety lamp. Carbon arc lamps were widely used in the middle of the last century for street lights, theatres, lighthouses and search lights. They were not particularly well suited for domestic use because of their harsh light, noise, odour and the heat emitted. Nevertheless, these lamps were popular for outdoor lighting.

Arc lamps were designed with two graphite electrodes held in place by a support and linked to two conductors. These in turn were connected to a source of electrical current. When the lamp was not in use, the two electrodes were in contact with one another. When they were pulled apart, the current flowed through the hollow coils (the electromagnet). This pulled the upper electrode away from the lower one and illuminated the lamp.

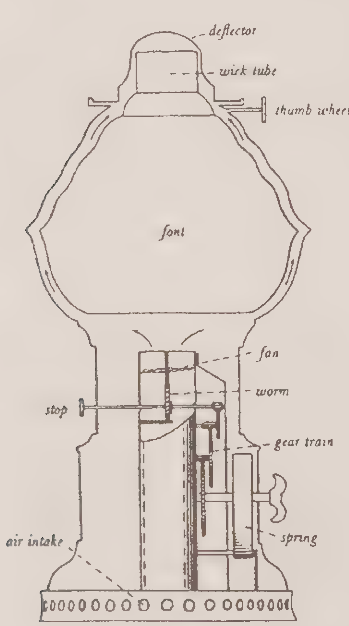
Gas Lights began to replace oil-fuelled lights in the 1840s. Although this type of lighting was not used for long, due to the advent of electric lighting around the turn of the century, it opened up many new possibilities for illumination in Canada's growing cities. A wide variety of cast-iron fixtures became popular, many of which are available today as reproductions.

Electric Lighting revolutionized exterior lighting on city streets and on building façades. A new demand for light fixtures, bulbs, and signage was created around the world.

3.0 PERIOD LIGHTING IN CANADA

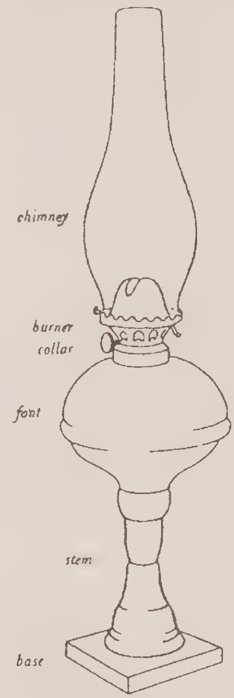
Canadians adapted various light fixtures to suit local requirements and the availability of fuels. The invention of kerosene by a Canadian and its widespread distribution revolutionized domestic lighting in this country and abroad. New ways to force the fuel up the wick were developed which popularized the mechanical lamp. Some had fans inside to ensure a continuous flow of air between the wick tube and the draft deflector of the burner. A small motor was located on one side of the base and this in turn drove the fan. Air was pulled upwards by the fan to the space between the font and the outside shell. In turn the air reached the burner deflector and provided enough draft to make a chimney unnecessary.

Richard Matt Wanzer, a successful sewing machine manufacturer from Hamilton, ON, received a Canadian patent for this type of mechanical lamp, although it had been invented by Abel Grove Heath of New York City. Wanzer's lamps were popular in Hamilton, Philadelphia and Niagara Falls. These nickel-plated pressed brass lamps with glass shades were odourless and produced no smoke. Since kerosene was readily available, the Wanzer lamp was widely used in eastern Canada.



Wanzer Lamp (Russell)

At the same time, oil was being extracted near Petrolia, ON, following its discovery by James Miller Williams, a Hamilton manufacturer of railway cars. He shipped crude oil to Hamilton in 1858 and two years later a refinery was in operation where Williams made kerosene and then sold lamps. Concurrently the United States was also developing its petroleum industry in Pennsylvania and various new light fixtures were developed to meet the new market demand for kerosene lamps.



(From Russell)

Another Canadian development was the invention of the carbon-arc lamp by Thomas Leopold Willson in Hamilton in the 1880s. Willson subsequently invented acetylene gas. Acetylene is produced when calcium carbide is mixed with water; when ignited, a very bright white flame is produced. In the late 1890s many public places were lit with acetylene. It did not become popular for domestic use due to its unpleasant smell and the corrosiveness of the carbide. Nevertheless, it was widely used for cars, motorcycles, bicycles, miners' lamps and lighthouses. Acetylene fixtures produced a controlled

trickle of water which, when combined with the calcium carbide, emitted a continuous supply of acetylene gas which was conducted to a special burner.

3.1 THE PRESERVATION AND RESTORATION OF PERIOD LIGHTING SYSTEMS

When the preservation or restoration of a period lighting system is undertaken, it is important to conduct a thorough investigation of the building's existing and preceding systems. Vestiges of wires, pipes and light fixtures are important clues and combined with other forms of research, can lead to a good understanding of the former lighting systems. A comprehensive examination of the existing condition of any wiring should be undertaken as well.

When restoration work involves the re-creation of fixtures and particular lighting levels, it is most important that these be accurate in order to create the proper interior ambience. The decoration of fixtures should be in keeping with the interior design and not a lamp fixture from another era. Both the selection of fixtures and type of lighting system are important to the success of a period room, whether domestic or institutional.

For more details on the period lighting systems, the reader should consult Vol. III.6.3 "Period Lighting."

4.0 BIBLIOGRAPHY

Berthier, A. 1905. "Some New Modes of Lighting," *Annual Report of the Board of Regents of the Smithsonian Institution 1904*. Government Printing Office, Washington, DC, pp. 267-74.
This article focuses on the development of incandescent petroleum oil lamps, early electric lighting, and mercury vapour lamps. It is a detailed and technical discussion of these late 19th-century and early 20th-century lighting systems.

Blalock, Tom. 1978. "Reviving An Old Lighting System," *The Old House Journal,* Vol. 6, No. 11 (November), pp. 125-27.
This article includes a clear, concise discussion on lighting and wiring systems in mid-19th-century houses and discusses how to repair an old system.

Bright, A.A. 1949. *The Electric Lamp Industry*. Macmillan, New York.

Cooke, Lawrence, S., ed. 1984. *Lighting in America: From Colonial Rushlights to Victorian Chandeliers*. Revised edition. The Main Street Press, Pittstown, NY.
This book is a compilation of articles which appeared in *Antiques Magazine* from 1924 to 1983. It covers a wide variety of topics from rushlights and candleholders to brass chandeliers and the identification of different lighting devices. The book is well illustrated and clearly organized.

Ferro, Maximilian, and Melissa Cook. 1984. *Electric Wiring and Lighting in Historic American Buildings: Guidelines for Restoration and Rehabilitation Projects*. AFC/A Monogram Co, New Bedford, MA. Illustrations reprinted by permission.
This comprehensive, well-illustrated book is both a stylistic and a technical review of electric lighting in America. It is useful for the identification of the fixtures and wiring systems which one might encounter while undertaking a restoration project.

__________. 1983. "Electric Lighting & Wiring in Historic American Buildings: Guidelines for Restoration & Rehabilition Projects," *Technology and Conservation,* Vol. 8, No. 1 (Spring), pp. 28-48.
Largely part of the same text as above publication. This article also provides a very detailed look at electric lighting in the U.S. and the types of fixtures prevalent at the turn of the century and well into the 20th century as well.

Flaherty, Carolyn. 1976. "A Guide to Lighting the Old House," *The Old-House Journal,* Vol. 4, No. 7 (July), pp. 6-9.
A brief stylistic guide to lighting in America from Colonial days to the early 20th-century forms the focus of this article. Clear line drawings accompany the text.

Freeman, Larry. 1968. *New Light On Old Lamps*. Century House, Watkins Glen, NY.
Lamps used in each era from the early settlement of North America until the beginning of the 20th century are discussed in this book. It is a well-documented historical overview and the concluding chapter, "Old Lamp Parts: Reassembly and Adaptation," will be of interest to those who are restoring old light fixtures.

Hawkins, C. Malcolm. 1952. "Artificial Lighting in America: 1830-1860," *Annual Report of the Board of Regents of the Smithsonian Institution, 1951*. Government Printing Office, Washington, DC, pp. 385-407.
A very comprehensive article on mid-19th-century lighting which deals specifically with technological developments which led to cheaper and more efficient lights. It also discusses socio-economic trends and how light affected the growth and development of urban areas.

Hayward, Arthur M. 1962. *Colonial Lighting*. Dover Publications, New York. Original edition 1923, B.J. Brimmer Co., Boston.
American lighting devices of the colonial era are discussed in detail in this book. It includes a series of good illustrations which accompany the text on lamps, candleholders, and lanterns as well as a chapter on collecting lamps.

Hough, Walter. 1902. "The Development of Illumination," *Annual Report of the Board of Regents of the Smithsonian Institution, 1901*. Government Printing Office, Washington, DC, pp. 493-500.
This article is an overview of illumination from prehistoric to modern times. It discusses both natural as well as artificial methods of illumination including sunlight, fire, candles and lamps.

Millar, Preston S. 1915. "Recent Developments in the Art of Illumination," *Annual Report of the Board of Regents of the Smithsonian Institution, 1914*. Government Printing Office, Washington, DC, pp. 611-28.
A comprehensive article on early 20th-century lighting techniques includings tungsten and carbon filament lamps, the neon-tube, and mercury arc lamps. Three excellent time lines illustrating the development of various lighting techniques are included.

Myers, Denys Peter. 1978. *Gas Lighting in America: A Guide for Historic Preservation*. Heritage Conservation and Recreation Service. U.S. Department of the Interior, Washington, DC.
This book provides a good overview of gas lighting and the types of fixtures used in the United States during the 19th and early 20th centuries. The book is well illustrated with plates from trade catalogues, drawings, and period photographs.

O'Dea, William T. 1958. *The Social History of Lighting*. Routledge and Kegan Paul, London.
The organization of this book is by uses of lighting as opposed to types of lighting. It covers a wide range of topics including light for travel, worship and theatre performances.

Paton, James. n.d. *Lamps: A Collector's Guide*.
Primarily an illustrative book on the various types of lighting devices used throughout history, the study includes a discussion of lamps used for travelling, and for exterior as well as interior lighting.

Rambusch, Viggo Bech. 1981. "Historic Interior Lighting: Recreating 19th Century Fixtures for Capital Buildings," *Technology and Conservation,* Vol. 6, No. 4 (Winter), pp. 36-41.
An excellent article on the recreation of original light fixtures with examples from both the United States and Canada. It also discusses how to illuminate building interiors with these fixtures and meet modern requirements.

Russell, Loris S. 1968. *A Heritage of Light: Lamps and Lighting in the Early Canadian Home*. University of Toronto Press, Toronto.
This is the most comprehensive book on this subject in Canada. Accompanying the text are over 200 illustrations, drawings, trade catalogue pages and photographs. The book focuses on domestic lighting and technological developments of the 18th, 19th, and 20th centuries.

__________. 1976. "Early Nineteeth-Century Lighting" in *Building Early America*. Charles E. Peterson, ed. Chilton Book Company, Radnor, PA, pp. 186-201.
Early methods of artificial lighting as they developed during the 19th century is the topic of this chapter. The improvement of candlelight, oil lamps, burning-fluid, kerosene and gas lights are all discussed. Each light is illustrated with a photograph or a line drawing.

__________. 1979. *Handy Things to Have Around the House*. Chapter 4: "Lighting." McGraw Hill, Ryerson Limited, Toronto, pp. 91-115.
This study provides a good discussion of various lighting devices and the way in which they were used. It includes early oil lamps, lard lamps, kerosene, gas and electric lighting.

Seale, William. 1979. *Recreating the Historic House Interior*. Chapter 8: "Lighting." American Association for State and Local History, Nashville, TN, pp. 66-74.
This book includes a chapter on lighting historic interiors for both decorative and utilitarian purposes. It includes a historical overview of the development of interior lighting and how to decide what type of lighting is appropriate for a particular restoration.

Thwing, Leroy. 1958. *Flickering Flames: A History of Domestic Lighting through the Ages*. Charles S. Tuttle Company, Rutland, VT.
This historical overview of domestic lighting is a comprehensive book on all aspects of illumination. It is well illustrated and covers lighting devices from the stone age to modern times. Excellent glossary and illustrations.

Wells, Stanley. 1975. *Period Lighting*. Pelham Books, London.
Traditional lighting devices from Italy, France, Spain, England and America are discussed in this book. It provides a good historical overview of lighting in each country and since the source of many Canadian lighting devices is European, the book is a useful reference.

Woodhead, E.I., C. Sullivan and G. Gusset. 1984. *Lighting Devices in the National Reference Collection*. Environment Canada, Canadian Parks Service, Ottawa.
Objects in the National Reference Collection (largely from Canadian Parks Service's archaeological sites) are the focus of this book which discusses 300 years of artificial lighting in Canada. It is of particular interest to readers seeking information on specific lighting devices including their size and materials which were used and/or developed in Canada.

VOLUME VII

PERIOD CONSTRUCTION TECHNOLOGY

13.4

PERIOD SERVICING

FIRE PROTECTION AND SECURITY

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

This article discusses fire protection and security from an historical perspective. It discusses the principal causes of fires, the ways in which they were fought and the developments in building design and technology which were made in response to them. Most of the historical examples are drawn from Ontario.

Fire was the common enemy of pioneer homes and outbuildings. The wooden roof was especially at risk. Most fires were started by sparks from the building chimney, from burning brush and trees as a result of land clearing or from forest fires. To aid firefighting, a ladder was often permanently hooked over the ridge of the roof, usually near the chimney, which in turn led to a side wall ladder. This arrangement allowed fast access to the fire so that it could be extinguished with water passed up in pails. A fire out of control in the fireplace could be dampened down with water or smothered with a wet blanket or canvas.

When factory-made wood shingles came into common use, the threat of roof fires receded somewhat. These shingles could be more closely fitted to each other than hand-split shakes. They were nailed down and their smooth exposed surfaces were not as likely to catch fire as a result of sparks. Nevertheless, many building owners nailed wooden slats, in the form of a ladder, directly on top of the shingles so they could reach the chimney in the event of a chimney or roof fire. The ladder to reach the roof was kept nearby. Metal roof ladders, commonly found at country auctions today, were an improved substitute for those made from wood.

When a closely fitted shingle roof did catch on fire, the usual process was to remove the burning area, either with a spade or shovel or a special fire axe that had two blades at right angles to each other. Today they are sometimes mistaken for mattocks which would serve the purpose. The shingles were removed because the fire frequently was burning in the roof

Dawson Fire Brigade, Dawson, YT (National Archives of Canada)

structure beneath them, therefore pouring water on the area would not extinguish it.

William Briggs in *Early Pioneer Life in Upper Canada* stated that the settlers

> would often have to get out and fight the (forest) fire for days to prevent it from getting to their farm buildings.... One method of arresting the progress of the fire was by plowing a number of furrows so as to prevent its creeping along the dry grass....When the fire got in the vicinity of their buildings, the settlers would cover the roof and sides of the houses with blankets wet with water to prevent them from taking fire (Briggs, p. 249).

Fire was also an ever-present menace in towns built largely of wood. Houses had adjoining stables filled with stacks of hay. As well, many towns did not have a rubbish disposal system. Each municipality had its own system of coping with these problems. A major fire in Montréal in 1721 led to the passing of an ordinance requiring houses to be built of stone and to include, in the construction, fire-break gables. In Toronto, in 1800, it was decreed that each householder should provide two buckets for the purpose of extinguishing fires. Two ladders of specified length must be kept handy – one led from the ground to the roof and the other was secured on the roof to provide an approach to the chimney.

Early fire brigades were made up entirely of volunteers (a practice maintained in many rural communities today). As communities reached a size that required continual services, professional companies were established. In 1912, a Canadian committee of the National Fire Protection Association was formed and in 1913 the Ontario Fire Prevention League was established. By 1916 a Fire Prevention Branch of the Canadian Commission of Conservation was in place and in 1919, a Fire Prevention Branch of the Department of Insurance was established under the direction of the Dominion Fire Commissioner (the Dominion Fire Commissioner is now called Fire Commissioner of Canada (FCC)).

Municipal fire alarm systems, activated from fire alarm boxes throughout the urban area, were popular into the mid-20th century. Today they are usually restricted to interior locations.

2.0 FIRE HAZARDS

2.1 HEATING SYSTEMS

Domestic heating systems were often the cause of fire. The *fireplace* was usually four to six feet wide, made of brick or stone and built completely inside the house against an end wall. In some cases, presumably to save space within the house, it would be built of sawn lumber, placed horizontally and caulked with clay.

For safety reasons the fire was usually allowed to die down at night so that only a few embers were available in the morning to rebuild the fire. Numerous tin hoods were designed and used for this purpose, but few have survived.

Tin stoves and *pipes* were in vogue for a short period during the early 1800s, but by 1855 were replaced by *cast-iron stoves* used for both cooking and heating. Special models were also available for heating only. Stove pipes, which passed through walls and floors, presented potential hazards if the crossing points were not properly protected.

As basements became more universal, entrepreneurs designed *furnaces* that would be out of sight. These were of two types: *duct* and *ductless*. Fire hazards seemed to be limited to coal-fired furnaces. There was a danger of explosion from coal gases if the furnace controls were improperly set. *Hot water systems,* which were also widely used, could be fired by solid fuels or manufactured gas.

Coal oil stoves and heaters were popular from 1880 through to the 1930s. They were small, efficient and could easily be stored when not in use. They did not require a connection to a chimney so they left little evidence of their use in a building.

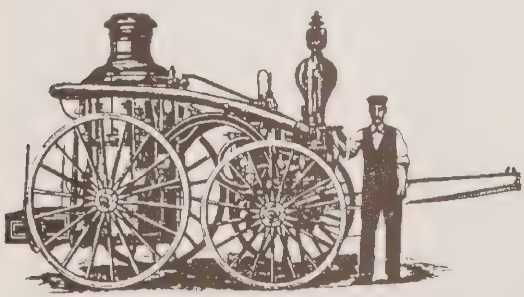
Ash disposal was a common cause of fires. Ashes were taken from the stove in the metal container supplied with the stove, which sat directly under the grates. However, this box was frequently allowed to overflow, resulting in ashes falling from the box as they were taken to a storage or disposal area. The kitchen, usually at the back of the house, led to a shed (the wood storage area). The shed often had a dirt floor covered with wood chips and bark from the splitting of fuel wood. It was usually the children's job to empty the ash box outside of the house – however in cold weather it was tempting to empty it on the earth floor for later removal. Hot coals fanned by a draft would catch on the wood scraps and a fire would start.

Some householders sifted their coal ashes into an ash barrel to salvage the small unburnt pieces of coal that had fallen through the grates.

2.2 PROTECTIVE DEVICES FOR HEATERS

Stoves were first set in a *bed of sand* held in place by a wood frame, later to be replaced by *stove boards*, a metal-covered wooden platform. Not all stoves sat on *legs*, but when these were used, the air flow under the stove cooled this area, lessening the danger of heat transfer.

After it was realized that tin would reflect stove heat away from combustibles, *heat reflectors* were used behind the stoves. *Chimney thimbles*, which ensured a tight fit for the pipe at the chimney, were developed. *Flue ventilators* allowed the safe passage of tin pipes through floors and walls. *Tin smoke pipes* were removed at least once a year for cleaning. At that time they could be inspected and replaced as required. The *stove pipe damper* was an important component that regulated the flow of smoke (and heat) from the stove. If opened too far, excess heat could burn the creosote and start a chimney fire. The importance of clean chimneys was recognized by public willingness to pay for chimney cleaning. The profession of chimney sweep is acknowledged even today.



From Pictorial Album of American Industry

2.3 ARSON

Arson was believed to have been responsible for many fires. The following extracts from newspapers in 1865 give some idea of the magnitude of suspect fires:

> Niagara, 28 April 1865. The woolen factory of the Hon. John Simpson was destroyed by fire.... The factory had not been occupied for four or five years.... There was no insurance. There is no doubt that the fire was the work of an incendiary (*The Patriot*, Toronto, 3 May 1865).
>
> Brantford, 27 April 1865. Two brick buildings... on the corner of Colborne and Queen Streets were destroyed by fire.... There seems to be no doubt that the fire was the work of an incendiary (*The Patriot*, Toronto, 3 May 1865).
>
> Niagara, 27 April 1865.... a fire broke out in a building occupied by a barber shop. The flames communicating to an adjoining building.... Both buildings were burned to the ground. The fire engine and hook and ladder wagon were promptly on the spot.... The fire is supposed to have been the work of an incendiary (*The Patriot*, Toronto, 3 May 1865).
>
> Ingersoll, 29 April 1865... a two storey frame building in the rear of the Caledonia block was discovered to be on fire. It spread to six other business premises – all of which were consumed in spite of the energetic exertions of the fire companies and citizens.... The fire is supposed to have originated from ashes taken from the Caledonia block and deposited in the frame building in rear of it (*The Patriot*, Toronto, 3 May 1865).
>
> Simcoe... Neville's hotel and stable were destroyed by fire…. He had no insurance. The fire originated in the hayloft and is supposed to be the act of an incendiary (*Weekly Leader*, Toronto, 10 March 1865).

3.0 FIREFIGHTERS

3.1 BUCKET BRIGADES

The bucket brigade was one of the earliest forms of public responsibility towards fire protection. It was a method employed in various ways by rural and urban dwellers; the form depended on the number of participating people.

When a fire alarm sounded, a double row of citizens formed from the burning building to the nearest water body, cistern or pump. Buckets of water were passed along one side and the empties returned along the other. In Toronto, wardens wore a white handkerchief on the left arm above the elbow as

a distinguishing badge of authority. Anyone who did not obey them could be fined from twenty to forty shillings.

Bucket brigades were the main firefighting units until the formation of volunteer fire companies.

3.2 VOLUNTEER FIRE BRIGADES

Fire departments, when first established, were composed entirely of volunteers and were formed as a response to the need for an organized firefighting body. Different municipalities organized at different times. The formation of the Bytown (Ottawa) Volunteer Firemen is descriptive of many municipalities.

Bytown had a number of fires within and near the village which could have been disastrous for the inhabitants. The fires were held in check and extinguished by the populace under the command of the Justices of the Peace. In these emergency situations, persons of all levels of society, including the military, helped out.

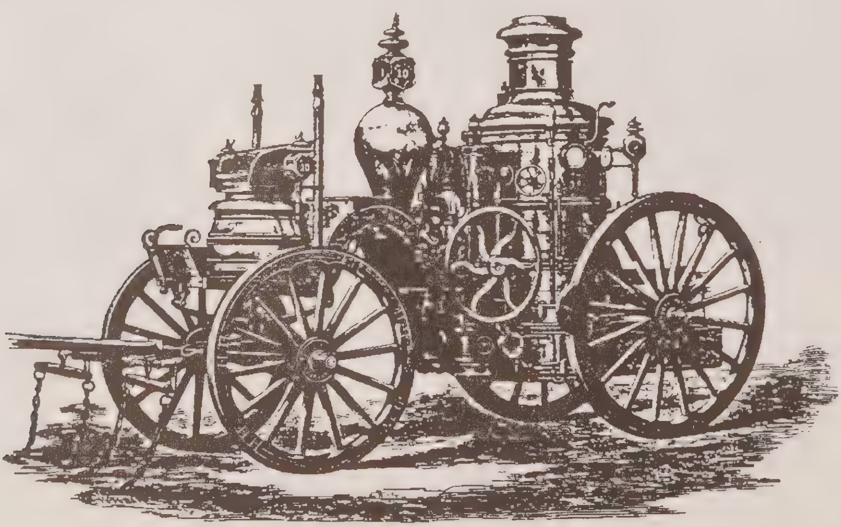
As a result of these close calls, a few individuals organized a subscription for the purchase of a small, but efficient, engine, which was stationed in a shed at the corner of Lyon and Sally (Queen) Streets in Upper Town. The volunteer firemen operating the engine later became known as the Mutual Company. The Army also had an engine at their barracks in Lower Town.

As a result of a disastrous fire on 14 July 1836, a public meeting was held to raise funds to purchase a fire engine and to form a fire club in Lower Town. As a result, a British-built fire engine was purchased from the Alliance, British and Foreign Life Assurance Company of London. It arrived in November 1837 and was named "Alliance" after the company that sold it.

To encourage service, the law exempted volunteer firemen from militia duty in peacetime or from serving as jurymen or constables.

When an alarm sounded, the members of the fire companies ran to the engine (pump) stations and pulled their engines to the fire. There was no shortage of help to pull the pumps if they were short-handed, but the hose work was reserved for the firemen.

The municipal council paid the cost of the water used to extinguish a fire. The first water vendor on the scene with a puncheon (72 gallons) of water was paid one pound, the remaining vendors at a lesser rate.



From Pictorial Album of American Industry

There does not appear to have been a comprehensive record of when various municipalities were first served by volunteer fire companies.

The following list of fire companies for Upper Canadian (ON) municipalities in 1846 was taken from *Smith's Canadian Gazeteer*, as were the population figures. It is not a complete list – there may have been other fire companies that municipalities failed to note.

Belleville (2040) – One fire company with two engines and a hook and ladder company.

Brantford (2000) – A fire company with one engine.

Bytown (7000) – Two fire engines.

Dundas (1700) – A fire and hook and ladder company with one engine.

Guelph (1240) – A fire company.

Hamilton (6475) – An engine house (with two engines).

London (3500) – A fire company with one engine.

Niagara (population not stated) – A fire company with two engines and a hook and ladder company.

Peterborough (2000) – A fire company with one engine.

Picton (1200) – A fire and a hook and ladder company, with one engine.

St. Catharines (3500) – A fire company with two engines.

Toronto (19 706) – Four fire companies with four engines, two hook and ladder companies, a hose company and a property protection company.

3.3 MUNICIPAL FIRE DEPARTMENTS

Ottawa also serves as an example of the evolution of municipal responsibility for fire protection. In 1848, the Hook and Ladder Company was unable to meet a debt of £13. It petitioned the municipal council to take over its indebtedness, which it did. Now that a precedent had been established, the other fire companies presented their accounts for payment. By accepting them, the municipality became responsible for fire services.

Municipal fire wardens were appointed for each ward. A new engine company and two hook and ladder companies were established. A bylaw authorized an officer of the fire company to requisition any horse and driver to draw the engines to the fire – as well, a reward of 20 shillings was paid to the first engine company to play water on any fire. If a horse was not available, passersby could be ordered to draw the engine.

As a result of the Carleton fire of 1870 and knowledge of the Chicago fire of 1871, Ottawa, remembering its narrow escape from destruction, approved plans for a waterworks department. In 1875 the first tap water was delivered. Formerly, water had been drawn from the Ottawa river and delivered by horse-drawn puncheons.

When the new waterworks system was in place, the municipality purchased its first steam engine called the "Union." It had a pumping capacity of 1400 gallons per minute. Most steam engines could pump water seven or eight minutes after lighting the engine fire. As these machines replaced hand pumps, the technique of fighting fires completely changed. In December 1874 firefighting duties were taken over by a professional fire brigade.

4.0 FIREFIGHTING EQUIPMENT

4.1 LADDERS AND SAFETY NETS

Ladders, as mentioned above, were one of the earliest tools used to combat fire. Their availability to reach roofs and chimneys was often required by law.

Swiss drawings from 1789 illustrated sectional ladders fitted with sockets which allowed several to be joined together. Wheels were sometimes added to the ends of the top sections so that the ladders could be more easily rolled up walls. Similar extension ladders were used in London in 1832. The average length of a section was six feet (2.0 m). In 1837 an Englishman, Abraham Wivell, invented the first portable ladder on wheels designed exclusively for fire evacuation.

The fly-ladder was the next major innovation. The primary ladder in this unit was approximately 35 feet (10.6 m) long and was mounted in a spring carriage with wheels. A further 20-foot (6.1 m) extension – or "fly" – was hinged to the top of the main ladder. A separate short ladder could be added to reach a height of 60 feet (18.3 m). For the very brave or the

very frightened, two canvas chutes could be attached to the underside of the ladder supported by copper wire netting. This chute was not suitable for great heights.

Telescopic ladders, which could be attached to a gear system on the engine and raised to various angles, were introduced in 1890. Another innovation, this time developed by the French, was known as the "pompier" ladder. This light apparatus 16 to 18 feet (4.9 - 5.5 m) long, had steel ends shaped like hooks. These ends could be secured over window ledges and provided an increased measure of safety.

A wide variety of chutes and safety nets for persons jumping from buildings were available commercially or were made locally. The Pembroke *Observer* on 13 November 1863 carried the story of a fire where an infant was dropped and safely caught in an outstreched blanket held by onlookers.

4.2 FIRE ENGINES AND PUMPS

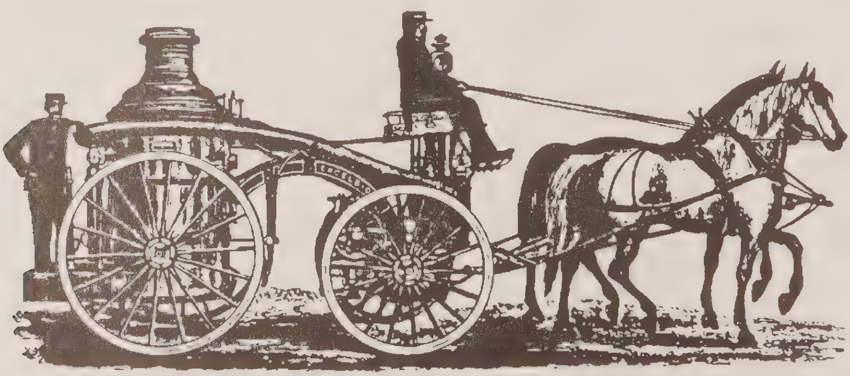
Firefighting equipment today performs the same basic functions as those of the early 19th century: they carry firefighters, equipment and pumps to the scene of a fire.

The first mechanical pumps (engines) were hand-operated. They required a number of persons to keep adding water to the open tank so it could continue to pump a steady stream. One was known to have been used in Europe in the 1700s. Toronto received its first pump in 1802. Pumps could be drawn to the fire scene by men or horses. The hoses and ladders were carried on separate vehicles.

With the invention of the steam engine in the early 19th century, hand-operated pumps were gradually replaced by steam-operated ones. The first fire machines appear to have been introduced in Augsburg, Germany, in 1518. They were referred to as "instruments for fires" and "water syringes useful at first." One machine, noted in Nurnberg in 1657, was described as having "a water box eight feet long, four feet high and two feet wide. The pump was worked by twenty-eight men and threw a stream of water, one inch in diameter, a distance of 80 feet." In 1841 the first steam engine was constructed in North America. Many manufacturers produced their own variations and each model added further efficiency. The "Victory No. 1" was built in Yarmouth, NS, in 1866.

Steam fire engines caught the imagination of the public and large international competitions such as the one at the Crystal Palace in London in 1863 were held.

Efficient use of a steam fire engine required a municipal piped water supply. However, the engine could pump from a pond or river if it were close enough to the fire.



From Pictorial Album of American Industry

Steam fire engines (pumps) were originally horse-drawn. They were replaced early in the 20th century by the internal combustion engine, which not only powered the vehicle to the fire, but also operated the pumps. Vancouver, BC, had one of the earliest motorized fire departments in North America. A "self-propelled" engine – the first in Canada – joined the force in 1908 and the last horse was retired in 1917. Some steam engines remained in service until the 1930s.

Chemical fire engines which sprayed soda acid solutions or foam (soda and aluminium sulphate solutions) were also developed.

Boats with steam fire engines (pumps), available by the late 1860s, may have been available for service at any of our inland or saltwater ports. They may have been operated by the harbour authorities or the British and later the Canadian navy.

Some pumping systems were permanent installations in buildings.

4.3 ALARMS

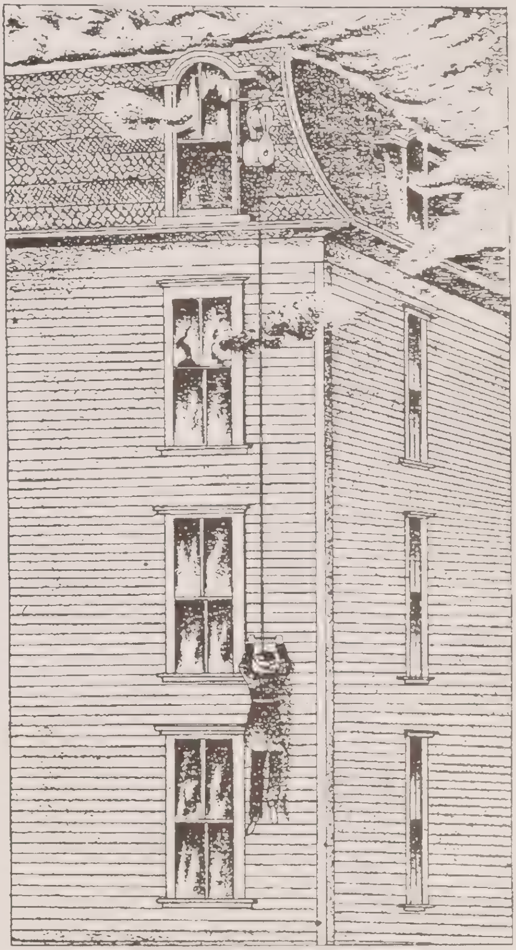
Toronto provides an example of early fire alarm systems. Up to 1848 the first person to notice a fire ran to the fire captain's residence and rang the alarm bell placed over the door. The fire captain blew a general alarm on a trumpet and the citizenry took up his cry of "Fire."

After the town hall was erected in 1877, a bell was hung in the tower. When a fire was discovered, the first person to reach the rope tolled the number of the ward where the fire had broken out, then kept up a clamour to waken the town.

In 1856-57, American Charles T. Chester invented a fire alarm signal device which any unskilled person could use by pulling on it. In 1869-70 he further developed this idea and produced a machine which allowed one man to receive notice of a fire from a large number of locations and then notify one of hundreds of fire stations to handle the call. This system was first utilized in New York.

The first automatic alarm system in Toronto to use electric wire was installed in 1874; the present system was installed in 1941.

Traditionally, fire alarms have taken the form of drums, bells and trumpets, followed by electrical warning systems sometimes supplemented by watchmen. However, the cry of FIRE! FIRE! FIRE! FIRE! is the oldest system and is still widely and effectively used.



*Fire Escape (*Pictorial Album of American Industry)

4.4 FIRE ESCAPES

The term "fire escape" was used differently in Europe and America, at least until the mid-20th century. In Europe, fire escapes were not "staircases" attached to building façades but rather were portable fire ladders, mounted on wheels, used by firefighters either from the ground or from a fire truck.

Early North American buildings may have been served by one or more of the following exterior systems of fire escapes: open iron stairways, open wooden stairways and chute or slide escapes.

The open iron stairway was the most common type of fire escape used. It could be added to the outside of any building, preferably against a wall with few windows to ensure that the smoke from the windows did not interfere with an orderly evacuation. This was seldom possible where buildings abutted each other. For security purposes, the lowest section of the system was held up in a horizontal position by a balance which dropped automatically to the ground with a person's weight.

Open wooden stairways were also used, but required continued maintenance and periodic replacement. They can only be used today under severe restrictions outlined in the *National Building Code*.

Chute or slide escapes, usually made of sheet metal, could be spiral or inclined, open or fully closed. These were principally designed for institutions such as schools and hospitals. For hospital use it was thought patients could be evacuated on their mattresses; however, the danger of a mattress jamming in the chute must have been common, as must have been the pile-ups at the bottom of the chute. Presumably staff cleared the exit for the next person down. They are not now in use in Canada.

A number of patent fire escapes were available in which pulleys were used to lower escapees to the ground. The devices had to be attached to a bracket outside the building. Judging from illustrations, they would appear to have been clumsy for women and children to operate. As there is little mention of them in contemporary literature, they are not believed to have been widely used.

4.5 LIGHTNING RODS

Lightning rods or conductors were touted during the latter part of the 1800s as the cheapest form of fire insurance available. A cursory survey of older buildings indicates that the majority of building owners believed this, as remnants of the system survive today. Benjamin Franklin started the trend with his invention of the lightning rod in 1753. He theorized that tall, pointed, grounded rods on buildings would discharge an overhead thundercloud and would also protect a structure by harmlessly directing any flashes to earth. Science has since proven that lightning conductors cannot release sufficient charge to either prevent lightning or to influence its production. It was also proved that their sole function was to intercept ground flashes and to harmlessly dissipate the current to earth. By the late 19th century, metal plumbing systems which vented on the roof and were well grounded in the earth were becoming a feature of most homes. These systems did not require lightning rods. Twentieth-century electrical wiring systems provided additional "built-in" conductors. As well, an urban environment offered the protection of a wide variety of taller elements as conductors for these dramatic discharges.

In rural areas, barns, silos and other outbuildings – which were largely unserviced – continued to require the protection of lightning rods.

If lightning rods are reinstalled on a heritage building, they should be checked annually to ensure continuity of the wiring from rod to earth. There is no requirement for lightning rods in the *National Building Code*.

4.6 AUTOMATIC SPRINKLER SYSTEMS

The automatic sprinkler as we know it today was invented in 1874 by H.F. Parmalee of New Haven, CT. Very popular by 1882, its use was regulated by individual standards of fire underwriting companies. By 1895 these standards were as numerous as the insurers.

The need for uniformity in fire protection standards resulted in the formation of the National Fire Protection Association (USA), which developed the "Standard for the Installation of Sprinkler Systems." This standard was numbered 13 and was issued in 1897. To prove that they meet the standard, today all sprinkler manufacturers have to obtain Factory Mutual, Underwriters Laboratories or other approved testing agency acceptance of their product to NFPA 13.

Automatic sprinkler systems were mainly installed in buildings which would have been unoccupied during a portion of the day. Their purpose was to provide an early fire warning system as well as to dampen down the area where the sensing element indicated a fire in progress.

In its earliest form the system would activate alarms within and outside the structure. With advances in technology, the signal could be transmitted by wire to any source, but particularly to police and fire departments.

The regular use of sprinklers in heavy-timber warehouse structures led to the development of a standard spray dimension of about 13 or 14 feet (4 or 4.2 m) – the throw of a sprinkler.

4.7 HOUSEHOLD AIDS

Numerous household elements and devices were employed to combat fire. Water was usually the first and best resort. It could be drawn from supplies stored indoors for household use or stored outside in barrels fed by roof runoff. The latter was accessible only in warm weather. Snow could be used in the winter. Wells, lakes, rivers and ponds were also early sources of water to fight fire. In the 18th and 19th centuries, water was often stored in cisterns located in the attic or basement. However, they were not always accessible during a fire. The most recent source of supply – municipal water systems – appeared in Canada from the 1830s onward as individual towns reached an appropriate stage of development.

a. Salt and soda were both used for stove fires. Long known as effective firefighters, the materials only worked if they completely covered the fire.

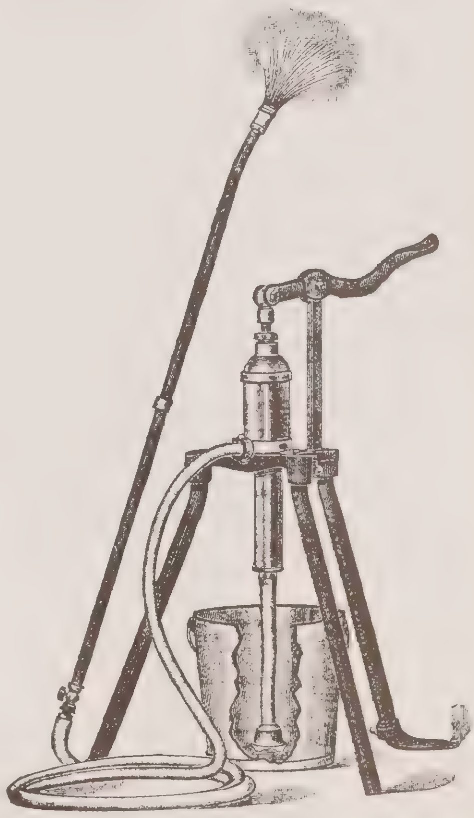
b. Wet blankets dampened stove fires when pushed into the fire box. They could also effectively smother fireplace flames. This was a common method known by all and no doubt reluctantly used, but losing a blanket frequently saved the dwelling. Using a blanket to smother clothing fires was also known.

c. Shovels, brooms, axes and mattocks were tools used to beat out or remove burning material from a building.

d. Plowing furrows around an area was a common method of stopping the advance of fire. The setting of controlled backfires also was used, even though there was the danger that the fire might spread to another property.

e. Fire pails – despite municipal requirements that a pail or pails be kept exclusively for firefighting purposes, they were frequently stolen, misplaced or misused. Early 19th-century pails were frequently made of leather, then later of wood or tin. To ensure they were not removed for other uses, they were manufactured with round bottoms. The pails had to be hung up as they could not stand on their own.

f. Fire hand pumps – in the late 1800s a number of manufacturers produced hand-operated pumps which could be used with pails or tubs. They were chiefly used in agriculture. Many of the advertisements wisely noted that the pumps would also be useful in putting out small fires. Because the nozzle pressure was between 50 to 100 lbs (22 to 45 kg), the pump could throw a solid stream a distance of 50 feet (15 m). More efficient fire pumps for household and forestry use were developed on the same principles.



From Sears, Roebuck Catalogue, *1908*

g. Fire extinguishers – in addition to household aids, "packaged" materials or fire extinguishers were available to the homeowner. There are five basic types:
   - soda-acid and foam to create the pressure which expels the fire retardant
   - vapourizing liquid extinguishers used on electrical apparatus and motor vehicles

- liquid carbon dioxide, when compressed to a gas, extinguishes fires by excluding oxygen
- dry powder extinguishers spray an inert powder which cools flames and to some extent, excludes the oxygen.

h. Ladders – every rural home had permanently attached ladders and moveable ladders to allow access to the roof to fight fires and clean and repair the chimney. Most rural families made their own wooden ladders.

i. Escape ropes – many residences (and hotels) attached hooks or eye bolts into bedroom floors so that coiled rope could be attached and used to escape a burning building. Where possible two per floor were used – one at the front and one at the rear (or side) of the building, so that if flames were coming from a lower floor window directly below the escape route, the other could be used.

5.0 FIRE INSURANCE

5.1 INSURANCE COMPANIES AND FIRE MARKS

Fire insurance can be said to date from the Great Fire of London in 1666. By the turn of the 18th century, a number of companies provided this service. In 1816, fire insurance companies appeared in France and by 1827 similar services were available in Russia.

During the early 1800s, these companies began to pool their data in order to provide a more accurate and uniform basis for calculating rates.

In 18th-century America, the new business of fire insurance was increasing. Those companies took over the responsibility of providing professional firemen and fire stations. Each building they insured was provided with a "fire mark" or sign to identify them. When an alarm was sounded several different fire companies might respond. However, only if the building was insured by their company would the fire be dealt with. The fire companies frequently relied on volunteers to staff the pumps. They were often paid in beer for their services.

In Canada, a number of municipal and parish fire insurance companies operated from the mid-1830s in both Upper and Lower Canada. In addition, large London companies served the Dominion.

5.2 FIRE INSURANCE MAPS

Fire insurance maps provide one of the richest sources of information on the development of urban Canada. A fire insurance atlas or plan is a map or set of maps of a community showing in detail, by means of colour and symbol, the character of the outside and inside construction of buildings, passages, probable fire cutoffs, fire walls, openings in walls, height and occupancy or use of individual buildings or groups of buildings. Also indicated are street widths, street numbers, property lines and fire protection facilities such as water pipes or mains, fire hydrants and fire alarm boxes. They were usually drawn in either multiples or fractions of 100-foot (30m) units.

These plans were used by fire insurance underwriters to determine the physical characteristics of structures to be insured and how the various policyholders were distributed. Because they formed the basis on which premiums were determined, these plans were subject to constant revision. They were updated by pasting correction slips on the plans until a new edition was prepared.

6.0 FIRE SAFETY INFORMATION BULLETINS

National Fire Protection Association. Boston:

Protection of Library Collections.	1970	NFPA 910
Protection of Museum Collections.	1974	NFPA 911
Central Station Protective Signalling Systems.	1974	NFPA 71
Local Protective Signalling Systems.	1974	NFPA 72A
Auxiliary Protective Signalling Systems.	1974	NFPA 72B
Automatic Fire Detectors.	1974	NFPA 72E
Portable Fire Extinguishers: Installation, Maintenance and Use.		NFPA 10
Life Safety Code.	1973	NFPA 101
Carbon Dioxide Extinguishing Systems.	1973	NFPA 12
Halon B01 Systems.	1973	12A
Installation of Sprinkler Systems.	1974	NFPA 13
Dry Chemical Extinguishing Systems.	1973	NFPA 17
Standpipe and Hose Systems.		NFPA 14
Fire Protection Guide on Hazardous Materials.	1972	SPP-1A.

Public Works Canada. Ottawa:

Electrical Fire Safety.	1976	No. 21.
Fire Emergency Organization in Government of Canada Occupied Buildings.	1979	No. 22
Fire Retardant Treatments for Wood.	1977	No. 2
Fire Safety in Federal Government Properties	1979	No. 15
Model Manual of Fire Emergency Procedures.		No. 22A
Standard for Fire Alarm Systems.	1979. DFC	No. 410 (M)
Standard for Fire Extinguishers.	1976. DFC	No. 401 (M)

7.0 BUILDING REGULATIONS

In Canada, building regulations and codes are a provincial responsibility but are administered at the municipal level.

Fire protection, the responsibility of the municipality, was developed "after the fact" in response to ratepayers' demands for protection. In almost all cases, it was a voluntary service formed and supported with money raised by public subscription. Municipal control began when the costs of maintaining the service became too heavy for volunteer organizations or when the municipality passed bylaws to assist volunteer activities.

Fire protection regulations were affected by Canadian building construction practices. These practices were influenced by the evolution of French-Canadian building methods and materials. The exterior roof cladding for the earlier homes was of wood: board and batten, clapboard and shingles with the latter predominating, but the French Canadians quickly adopted sheet metal as a roofing form. It is assumed that the sheet metal was first brought into Canada from Europe, where it was manufactured in England and Saxony by the middle of the 17th century. Masonry construction quickly replaced the wood plank construction which was not as prone to catching fire.

In rural areas where the French subdivided their farms, the residential and farm buildings usually faced the same public roadways. In the event of a fire alarm, help could be obtained more quickly than in English settled areas where the farm residents were frequently out of sight of each other.

Fire protection measures were also influenced by the regulations laid down after The Great Fire of London. Buildings had to be constructed to prevent the spread of flames to neighbouring premises. A masonry wall had to separate joined buildings. These walls were to extend above the roof as a parapet – the object was to stop one roof fire from setting fire to the next. In addition, openings were not allowed in the spaces between buildings if the distance increased the danger of flamespread.

When this knowledge was brought to Canada by architects, carpenters and masons, it was not encoded. However, it was a thorough part of their apprenticeships and became accepted as custom and later the basis of our building regulations. Customs die hard – one still notices isolated stone houses in rural Ontario with stone parapets on the gable end, although they serve no useful purpose.

The group that had the most influence on building construction practices was the insurance companies – the group that had the most to lose. Their casualty statistics told them where the greatest risks lay. If the risk was too great, they would not insure or they would spread the risk among other insurance companies. They also looked for and encouraged new methods of fire prevention, both in building design and fire prevention equipment. Obviously, buildings constructed entirely of wood posed the greatest fire prevention problems.

Early detection and control of fire was essential to save the structure and to control the spread of fire to other buildings. Loss of life in low-level buildings, including those of wood, was usually minimal because it was easier to escape from them.

Wood residential and industrial buildings were frequently built up to four storeys tall. While some may have had exterior masonry walls (usually brick), the interior beams and wall structures were entirely of wood.

In their desire to build higher, designers started using cast-iron and steel structural members. However, major fires soon showed that heat generated by a fire would twist the metal framing into unrecognizable shapes and would completely destroy the building. This steel-framed building system probably prompted insurance companies and others to look more closely at building design. Obviously the steel beams needed heat protection. This was provided by encasing the steel in various plasters, asbestos or concrete. This allowed, under actual test conditions, a fire resistance rating to be determined.

Both the elevator manufacturers and the insurance companies were responsible for the first elevator-fire standards. Elevator shafts, which in their earliest days were protected only by open grillwork, were now enclosed to stop the spread of flame from floor to floor.

As buildings rose higher, emergency escapes were needed. In response, steel fire escapes were attached to the outside of buildings.

Improvements in building safety developed as buildings rose higher and higher. It usually took a major disaster and loss of life to encourage safety changes, which were then incorporated into new designs. Unfortunately the new rules or laws, then as now, did not necessarily apply to existing buildings.

The first federal attempt at regulating building construction occurred in 1935 when the *National Housing Act* was passed. It detailed the minimum construction requirements for residential construction.

The first edition of the *National Building Code of Canada* did not appear until 1941. It began as a compilation of existing municipal regulations, rule of thumb construction, scientific studies by industry and governments and educational institutions. The committee, then as now, was composed of experts in their respective fields of interest, aided by building officials, architects, engineers and contractors. The *National Building Code of Canada* only becomes law where it is adopted by the jurisdictional authority. For more on building regulations, see Section 1 "Construction Organizational Development in Canada" in this volume.

8.0 SECURITY: HISTORICAL OVERVIEW

8.1 CANADIAN LEGAL TRADITIONS

Canadian legal traditions are based upon two great European legal systems; the English Common Law and the French Napoleonic Code. The Common Law system, under which laws of past generations continued to be respected unless altered by specific legislation, is employed in all provinces and territories except Quebec. In that province, the system is identified as civil law. This tradition, used in most of continental Europe, evolved from the codification of Roman Law. As early as 1664, Louis XIV of France decreed that the French version of this code would apply to New France. Napoleon later further codified French law and custom. The *Quebec Act* of 1774 guaranteed that French civil law would, as applied in Quebec, be employed along with the English constitutional system. The Quebec system has therefore evolved as a hybrid.

8.2 PROPERTY PROTECTION – LAW ENFORCEMENT

The primary function of the police is to preserve order between persons in a community. This "order," written down and added to over the centuries, has become known as the law.

Before the "laws" were encoded, each town had its own rules, procedures, norms, accepted standards and customs. Whether based on church law, satisfactory usage or common sense, standards and customs were acceptable to the majority who wished them to be respected. Persons who broke the rules could expect some form of punishment from their peers. Prior to the 19th century order was kept in this manner.

The Industrial Revolution in England was responsible for large concentrations of workers in urban centres. These large populations required more control than could be administered by the village or urban peer group. A uniformed police force for the City of London was established by an Act of the British Parliament in 1829. At its inception it had 1000 men responsible for six divisions in inner London.

The London police model was adopted by many other jurisdictions, including Canada. The Canadian North-West Mounted Police was an exception because the widespread western territory required a more mobile, military-type force.

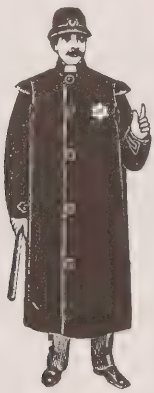
In Canada, the responsibility for preserving order between persons was assigned to the provinces, where it developed slowly.

The need for police in highly populated areas was met by a uniformed force established at the municipal level. Few rural municipalities had police forces. When needed, they called for expert assistance from the province. Once the provincial police force became established, it had the responsibility for law and order. Before then, these responsibilities rested with the magistrates and sheriffs.

Bytown (Ottawa) provides an example of how police forces were developed. In 1846, as a result of rioting during the Orangemen's celebration, a petition was sent to Governor Metcalfe requesting the establishment of a police force in Bytown to protect its citizens. The Governor said he had neither funds nor authority for such action. He advised that such a force should be established at the citizens' expense. A force was not formed until 29 May 1866. In the interim the magistrates, sheriffs and part-time constables (or those sworn in for the occasion), attempted to keep order. This frequently required the use of armed militia.

Each county had numerous justices of the peace as well as a sheriff. When an arrest was required, the evidence would first be heard by a justice of the peace who could authorize an arrest. The sheriff, if he required assistance, would call one or more volunteer constables to assist.

It appears that the faster the crime rate grew, the faster a full time police force was established – in many cases, a one-person force.



From Sears, Roebuck Catalogue, *1902*

The constables who assisted the sheriff in the Bathhurst, ON, judicial district and later the counties of Lanark and Renfrew in maintaining the law were once part-time officers. Carleton Place, ON, appointed a full-time constable in 1885 at a salary of $350 a year. In addition to his job as Chief Constable, he was Street Commissioner, Collector of Young Man's Statute Labour Tax and Sanitary Inspector.

8.3 RURAL AREAS

Rural and remote areas had less crime than urban areas for numerous reasons. The poor condition of early roads did not encourage outsiders to make unnecessary trips. As well, until the 1850s, farm life provided a marginal existence with little available cash to entice the prospective thief. People knew their neighbours well and co-operated with them. If there was a black sheep in the family, the person often migrated to urban areas. The extended family system almost always ensured an adult would be at home, thus discouraging theft. Every farmer kept a watchdog: the sworn enemy of tramps and vagrants. As well, most fowl and animals would make appropriate calls if human or animal predators were around the barns or pens. A person approaching a dwelling at night on foot would make a loud "HALLOO" so that he or she would not be facing the wrong end of a shotgun.

8.4 URBAN AREAS

Property security was a source of concern in towns and cities. Owners of commercial buildings or prestigious homes ensured their doors were soundly constructed with substantial metal hinges and locking devices. As well, basement and first floor windows were frequently faced with metal bars to prevent entry. Skylights were also barred to prevent entry from the roof. Smaller commercial establishments sometimes had living quarters over or near their premises which ensured some security. For privacy, as well as additional security, some windows had solid interior shutters.

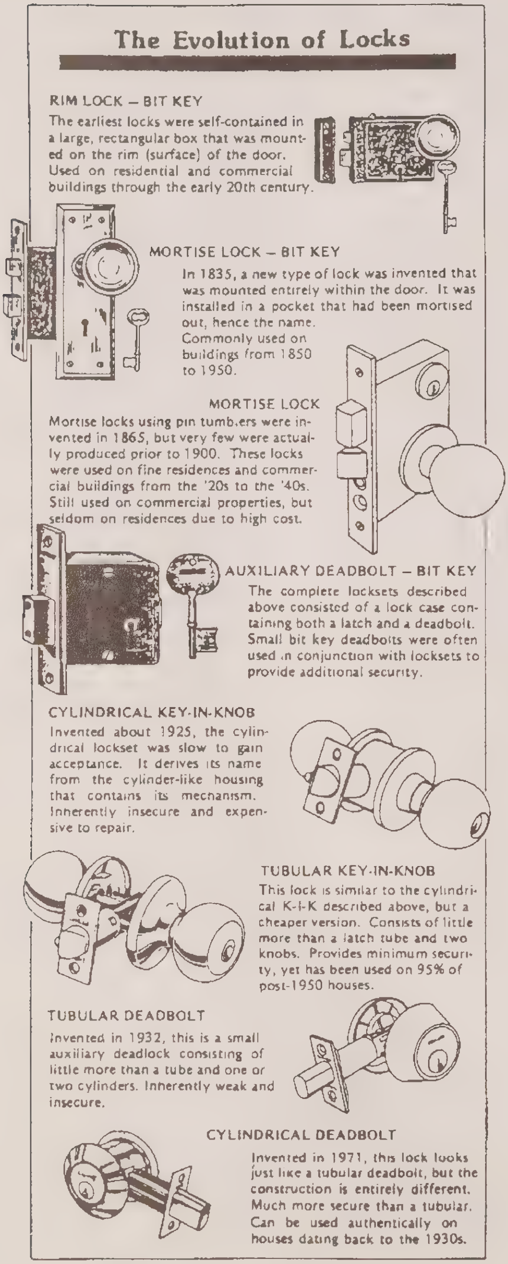
Business establishments, as well as some householders, had a bell system to ring each time a door was opened or closed.

To protect banks, the bank manager's residence would be installed on the second floor over the bank premises. The master bedroom would be directly over the bank vault. A conical opening was cast into the roof of the vault. It allowed a person in the bedroom to view the vault area and to fire a revolver at any angle into it. Return fire at the ceiling was relatively ineffective because of the small opening. However, the person firing from the bedroom could fire random shots, exposing only their hand near the opening. A plug, when needed, was inserted into the hole from the bedroom.

Servants, fairly common in upper and middle class homes up until the early 1900s, usually resided on the premises. At least one was expected to be there during the absence of the owners. This precaution was taken for fire safety as well as property protection.

8.5 LOCKS

Locks and their keys are known to date from ancient times. They are often mentioned in the Old Testament and remnants have been found in the ruins of Thebes, Herculaneum and Pompeii. In Egypt, sophisticated tumbler locks were known to exist from early times. As well, Chinese expertise over many centuries was well acknowledged. Very crude locks were known to have been used in Europe during the Middle Ages. The



The Evolution of Locks

RIM LOCK — BIT KEY
The earliest locks were self-contained in a large, rectangular box that was mounted on the rim (surface) of the door. Used on residential and commercial buildings through the early 20th century.

MORTISE LOCK — BIT KEY
In 1835, a new type of lock was invented that was mounted entirely within the door. It was installed in a pocket that had been mortised out, hence the name. Commonly used on buildings from 1850 to 1950.

MORTISE LOCK
Mortise locks using pin tumblers were invented in 1865, but very few were actually produced prior to 1900. These locks were used on fine residences and commercial buildings from the '20s to the '40s. Still used on commercial properties, but seldom on residences due to high cost.

AUXILIARY DEADBOLT — BIT KEY
The complete locksets described above consisted of a lock case containing both a latch and a deadbolt. Small bit key deadbolts were often used in conjunction with locksets to provide additional security.

CYLINDRICAL KEY-IN-KNOB
Invented about 1925, the cylindrical lockset was slow to gain acceptance. It derives its name from the cylinder-like housing that contains its mechanism. Inherently insecure and expensive to repair.

TUBULAR KEY-IN-KNOB
This lock is similar to the cylindrical K-I-K described above, but a cheaper version. Consists of little more than a latch tube and two knobs. Provides minimum security, yet has been used on 95% of post-1950 houses.

TUBULAR DEADBOLT
Invented in 1932, this is a small auxiliary deadlock consisting of little more than a tube and one or two cylinders. Inherently weak and insecure.

CYLINDRICAL DEADBOLT
Invented in 1971, this lock looks just like a tubular deadbolt, but the construction is entirely different. Much more secure than a tubular. Can be used authentically on houses dating back to the 1930s.

Courtesy of the Old House Journal, *1986*

famous Bramah lock was invented in England in 1784. Early locks were fabricated in wood, metal and exotic materials like ivory. Rim and mortise locks are the two principal types of early locks. The cylindrical deadbolt, a more recent innovation, was an improvement over the old tubular deadbolt.

Locking devices were available in Canada, but not widely used during the early periods of settlement. As there was usually someone at home, a wooden door latch was sufficient for daytime use. If all members of the family were absent then a latch string was left protruding through a hole in the door by which the latch could be lifted from the exterior.

Rim locks were so-called because the lock was fastened to the rim or surface of the door rather than mortised into the door. These locks, usually of English make, appeared in North America in the early 18th century. Dutch elbow locks, both latch and cylinder key operations, were used in North America from the 1740s until approximately 1830. They are found primarily in areas where German craftsmen settled. Early examples had wrought iron cases, but were later rendered in brass.

Keyhole door latches or plate latches were common in the 18th and 19th centuries. They were manufactured primarily in Staffordshire, England. Their use was confined to the interior of the house.

9.0 BIBLIOGRAPHY

B.C. Ministry of Municipal Affairs. 1979. *British Columbia Building Code.*

Canadian Fire Prevention Association. 1980. *Catalogue of Fire Prevention Materials.* Fiprecan, Ottawa.

Environmental Design. 1974. "Historic Fire Museum Safeguarded" (Spring), pp. 4.

Fidler, John. 1981. "Firefighting Systems for Historic Interiors," *Building Trades Journal,* Vol. 82, No. 5432 (December), pp. 34.

Fischer, Walter R. 1976. "Fire Safety Systems: Protecting Our Treasures from Threat of Fire," *Technology and Conservation* (Fall), pp. 14-17.

Herman, Frederick. 1978. "Avoiding Hazards from Lightning," *Old House Journal* (April), pp. 46-47.

Horton, Eva. 1977. "Chimney Sweeping," *Old House Journal,* Vol. 6, No. 8 (August), pp. 49-52.

Maatman, Gerald L. 1970. "The Consultant's Role in Fire Protection," NFPA reprint FJ70-10. *Fire Journal* (March). Boston.

McGuire, J.H., and G. Williams-Leir. 1981. *Spread of Fire Between Buildings.* Canadian Building Digest 216 (June), NRC, Ottawa.

Morton, W. Brown, and Gary L. Hume. 1979. *Standards for Historic Preservation Projects with Guidelines for Applying the Standards.* United States Department of the Interior, Washington, DC.

Nash, George. 1981. *Old Houses: A Rebuilders Manual.* Prentice-Hall Inc., Englewood Cliffs, NJ.

Ontario. Ministry of Consumer and Commercial Relations. 1981. *General Residential Renovation Guidelines.* Ministry of Municipal Affairs and Housing, Ministry of the Solicitor General, Toronto.

Parness, Alan, and David H. Ashford. 1978. *Fire Safety in Historic Buildings.* Technical Pamphlet 6. Society for the Protection of Ancient Buildings and the Fire Protection Association, London.

Schur, Susan. 1980. "Fire Protection at Mount Vernon: Incorporating Modern Fire Safety Systems into an Historic Site," *Technology and Conservation* (Winter). Boston.

Taylor, Dale L. 1981. "Fire Records: Their Importance and Use in Documenting Fire History," *Parks,* Vol. 6, No. 2, (July), pp. 13-14.

Tiszkus, Alphonse T., and E.G. Dressler. 1980. "Fire Protection Planning for Cultural Institutions," *Technology and Conservation* (Summer), pp. 18-23.

Vance, Mary. 1981. *Fireproof Building: A Bibliography.* Vance Bibliographies, Monticello, IL.

Windeler, Peter. 1970. "Fire Endangers the Past for the Future," *Museums Journal* (September), pp.72-74.

VOLUME VII
PERIOD CONSTRUCTION TECHNOLOGY

14
PERIOD LANDSCAPING

PRODUCED BY:
HERITAGE CONSERVATION PROGRAM
ARCHITECTURAL AND ENGINEERING SERVICES
PUBLIC WORKS CANADA FOR ENVIRONMENT CANADA
OTTAWA (819) 997-9022

ORIGINAL DRAFT: COMMONWEALTH HISTORIC RESOURCE MANAGEMENT

CONTENTS

1.0 INTRODUCTION

Period landscaping (or era landscaping) deals with those aspects of management which have shaped the landscape in the past and with those individuals who were responsible for instituting changes, as well as those who contributed to a Canadian landscape ethic.

Landscapes can become metaphysical symbols of culture and nature. In the treatment of our landscapes and gardens, we explore and express our relationship with nature. The forms or layout of a landscape are testimony to the period and tastes of its creator and users. Period or era, landscape architecture attempts to record and define those significant imprints on the land and to place the artifacts in a cultural and natural context. It encompasses not only gardens but also parks and the wider landscape. The interpretation of contiguous period landscape features is somewhat ambiguous and ill-defined. This stems from the characteristics of the artifacts which are constantly growing and changing. Also, the models for development are based on European examples and their application to a Canadian setting is not always consistent with the historical intent.

In Canada, designed landscapes (as opposed to randomly developed landscapes) have rarely had the degree of visual impact and social implication as, for example, the landscaped parks of 18th-century Britain or the formal estates of Europe. To some degree our landscape history is democratic and often response-oriented. The broad canvas of Canadian landscape examples derive mainly from a pioneering and often individualistic approach. Frequently these imprints are prototypes in that physiographic features dictated modifications to existing concepts and the materials which were used. Access, terrain and climate dictated the pattern of settlement and the location of our towns. The design of fashionable estates and humble gardens drew heavily on traditional models, but design was adapted to local conditions and showed an ability to modify those environments.

1.1 TECHNICAL DEVELOPMENT

Gardening is a domestic art. The great majority of our period landscapes are associated with houses. The 19th and early 20th centuries saw a lot of energy expended on municipal gardens and scenic drives. But in general, houses and gardens have gone together. Technical developments, mostly related to mechanization, have played a role in garden evolution and in resulting stylistic changes. Styles and tastes have sometimes changed with great rapidity, alternating in a general pendulum effect between formal and informal, naturalistic gardens.

Gardening has rarely been perceived as an important part of the visual makeup of the environment. Partly a matter of economics, this perception is mainly a result of scale, especially where the North American wilderness has overpowered manipulated and artificial attempts to mould the environment. Traditionally there has been a strong interest in botany and horticulture, in landscape design and in gardening.

In Britain and in parts of Europe the 18th century saw a revolution in popular taste in garden design. It reacted against formal gardens dominated by topiary in favour of a more natural look which became known as the English Landscape style.

The English Landscape style influenced the perception of landscape and also how landscape design developed. The rugged wilderness of North America suited a version of this style called Picturesque. The features commonly used – endless vistas, mature trees, controlled views, rock outcroppings and rushing water – were readily available in Canada. During the 18th and 19th centuries, travellers, when describing the Canadian landscape, spoke in terms of "romantic views" and "picturesque scenery." This to them meant picture-like in the tradition of the designed landscapes of Britain, where the design effort created a series of pictures as one moved through the landscape.

Nouveau riche merchants and manufacturers following the course of fashion eagerly adopted the Picturesque style for their estate landscapes. With the influx of Loyalists and other settlers into British North America in the late 18th and 19th centuries, interest and activity in gardening and garden design also expanded. As the American garden architect A. J. Downing explained in 1841:

> ...we think the Picturesque is beginning to be preferred. It has, when a suitable locality offers, great advantages for us. The raw materials of wood, water and surface by the margin of many of our rivers and brooks, are at once appropriated with so much effect and so little art, in the picturesque mode; the annual tax on the purse too is so comparatively little and the charm so great.

British military officers and government officials stationed in the colonies enthusiastically undertook the layout of grounds for both official and private residences. Topographic artists,

versed in the theory of the Picturesque landscape style and trained in arranging a visual record of the landscape, appear to have assisted in preparing some of these designs.

In the 18th and early 19th centuries, a knowledge of botany and an interest in horticulture were standard prerequisites for entrance into scientific society. Horticultural societies, modelled after the Royal Horticultural Society founded in London in 1804, were established in major colonial settlements. In Toronto, for example, the Agriculture and Horticulture Society was founded in 1834. One of the founding directors was D'Arcy Boulton, Jr., whose estate, The Grange, was testimony to his taste for the English Landscape style. By the mid-19th century most cities had both an agricultural and a garden society.

Increasingly from the early 19th century on, a proliferation of printed material dealing with horticulture, garden techniques and design was available in the British colonies. Collections of books in private libraries such as Richard John Uniake's and Charles Prescott's in Nova Scotia and in public collections like the Montreal Horticultural Society's indicated the scope and availability of written material. Publications prepared and edited by J.C. Loudon, as well as other English gardening authors, were influential in spreading the ideas of Picturesque gardening in Canada. By the middle of the 19th century, A. J. Downing was also a popular author among British North American gardeners. The Americans, Calvert Vaux and Frederick Law Olmsted, through their work on city parks and other public landscapes, later strongly influenced public garden design. It was not until the development of the federal experimental farm program in the 1880s that a major Canadian horticultural influence was evident. However, its major design thrust was toward plant material and utilitarian landscape design.

Because of the harsh climate, short growing season and unique living conditions, there was always a strong need in British North America to adapt garden styles, layout and material to the local environment. The problem of hardiness was noted as early as 1749 in Peter Kalm's journals:

> ...They [the settlers of New France] were obliged to send for fresh seeds from France every year, because they commonly loose (sic) their strength here in the third generation and do not produce such plants as would equal the original ones in quality (Kalm, p. 439).

Plant breeding and hardiness experiments have consequently played a vital role in the evolution of gardening in this country. Private individuals such as Frank Skinner at Dropmore, MB, commercial seed houses such as Steele, Briggs in Toronto, nurseries, as well as the Department of Agriculture, have done considerable work in the adaptation of plants and the layout of grounds. During its heyday the community of Dawson, YK, carried out extensive research in northern gardening. Much of this was recorded in the writings of Mrs. M.L. Black.

1.2 DEFINITION

The sense of period or era in gardening defines the process and the recording of the form and details of the various components which together make up landscapes as they appeared in the past. Those portions or features of the ground which are significant because of historic, landscape or cultural values can be broken down as components. For example, at Maplelawn in Ottawa, the landscape design, the circulation patterns and the walls are components of the garden which can be documented in 1834 plan drawings.

When working with a period landscape, there is often a juggling act between interrelated material components. These are broken down and set out in this article. Not every component is evident in every historic landscape, but all should be considered when identifying and analysing a period landscape.

1.3 PURPOSE

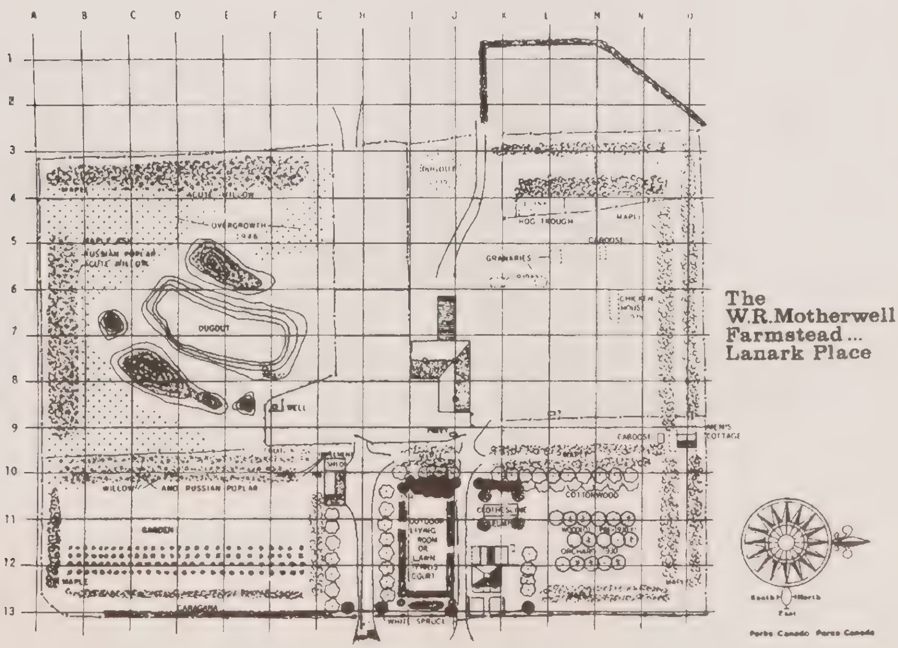
The purpose of this article is to provide a general view of period landscape construction practices in Canada, within the context of the technical and organizational development of individual trades, equipment, practices and terminology.

The conservation of our historic sites and structures requires a practical knowledge of period landscape installation and construction. Previously, little written information was readily available on this subject, thereby requiring considerable conjecture when creating a restoration design.

An adequate understanding of period landscape practices is becoming more and more difficult to document as mechanization and standardization take over the construction industry. Techniques known to the nursery trades are being lost as mass production continues to replace traditional practices. Since the period restoration and maintenance of historic sites is dependent upon well-informed designers and work crews, it is necessary to assemble as much information as we can covering period landscape construction technology.

This article is intended for use by consultants, professionals, technicians and supervisors who investigate, design or carry out work on heritage resources.

This article does not cover period maintenance practices (except what may be included in the referenced literature), nor does it include a detailed discussion of landscape analysis. See Vol. III.8 "Landscape Investigation and Analysis" for information on planning and conducting an investigation of historic landscapes or gardens. See also Vol. III.1 and Vol. III.2 for additional information on defining and co-ordinating investigations of historic sites.



2.0 COMPONENTS

2.1 LANDSCAPE SPATIAL ORGANIZATION

This component relates primarily to the large overall patterns of the cultural landscape. It deals with broad planning issues, the large-scale relationship among major components and predominant land forms, such as hills or ridges. Site clusters, field patterns, earth works and military battlements, canals and waterways are land-use activities which were imposed upon and which occupy large portions of the landscape. Recognizing how the physical forms encouraged and dictated site development is essential in assessing the totality of a landscape.

The topographical features and major components should be appraised for their overall importance to the site's original use. Land forms outside the site are frequently important adjuncts. The following material adapted from "Cultural Landscapes" provides a framework for determining the overall scope of a site.

2.1.1 Physiographic Context

Every historic district exists within a surrounding physiographic region. This larger landscape context helps to explain the site as well as contributing to our understanding of it. The physiographic context is defined by such factors as topography, predominant vegetation and water resources. It is the backdrop against which the site is set and eventually evaluated. Batoche National Historic Park, SK exists, for example, within the larger physiographic context of the rolling landscape of the Saskatchewan drylands. This physiographic context should be described through narrative, drawings and photographs. It should be recognized that while some landscapes develop in contrast, rather than in accord with the physiographic context, they still exist within that context.

2.1.2 Ecological Context

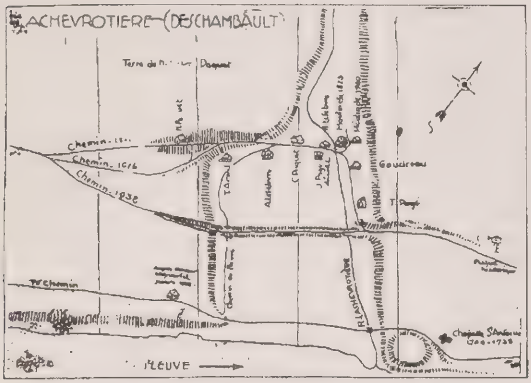
Within that physiographic context, there is a variety of more specific natural features which comprise the ecological context for the landscape. These features include hydrology, soils, vegetation patterns and biotic communities. The cultural forces which have shaped the area have interacted with and often altered those natural features. These features may be considered to be the raw materials available to the cultural group(s) responsible for the development and modification of the landscape. An understanding of the ecological context, in the broadest sense, allows for a general recognition of the landscape type and conditions faced by both the current inhabitants and their forebears. For example, Waterloo Township in Ontario was settled by the Mennonites, a religious sect of German origin. These settlers were convinced that the natural vegetation of a region furnished a reliable indication of its agricultural capability. Fertility of the soil was judged by the species, number and size of trees growing on it. Land heavily stocked with hardwoods, especially *Juglans nigra*, was preferred. Good wheat soils supported *Quercus, Ulmus, Fraxinus, Juglans, Carya* and *Tilia americana*. Second choice soils supported *Acer, Fagus* and *Prunus*. Least productive soils were treed with *Pinus, Tsuga* and *Thuga*. Building sites were carefully selected to avoid snow deposition problems and to provide other climatic controls.

2.1.3 Historical and cultural context

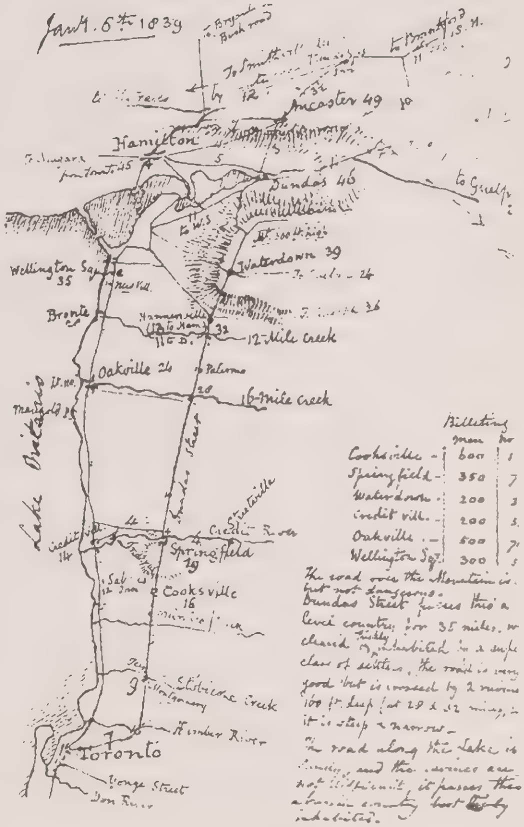
Prior to detailed identification of an historic site it is necessary to understand its historical development and its cultural origins. The historical survey should include knowledge about broad settlement patterns of the region, including its significant people; demography, both historical and contemporary; and significant social forces, political events, economic trends and anthropological studies. Archaeological surveys are desirable parts of the base information. Significant historical themes, periods of settlement, change and stabilization should be identified. This data forms the background information for historical resources which complements the physiographic and ecological data.

2.2 CIRCULATION NETWORK

Circulation networks range in scale from footpaths to highways. All road and path systems facilitate movement from one point to another.



This plan shows the shifting road system which dissected The Mill at Deschambault, PQ. The network of roads linking buildings relates to the period of construction and the changing needs.



A Route Sketch by the Military, Toronto-Hamilton, 1838-39. Phillip John Bainbrigge (1817-81), who trained at the Royal Military Academy at Woolwich, came to Canada as an officer in the Royal Engineers in 1836, travelling through from the Maritimes to Amherstburg, Upper Canada.

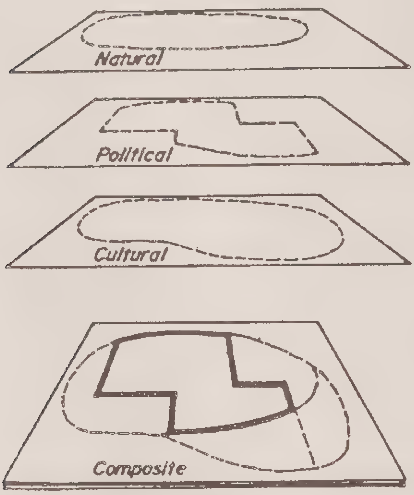
Networks may be internal to a landscape or they may connect that landscape to the surrounding area. For example, the Rideau Canal system is both a circulation network and also defines landscape spatial organization, land patterns and settlement patterns.

2.3 BOUNDARIES AND ENCLOSURES

Historic properties are defined by cultural, political and natural boundaries, although these are not necessarily coincidental. Cultural boundaries define areas which exhibit similar cultural identity. Political boundaries, such as county lines or park boundaries, are divisions imposed upon the landscape either in response to cultural boundaries and natural features or are arbitrary. Natural boundaries are those features such as rivers, valleys or ridges, which define watersheds, vegetative ecosystems and other natural areas.

A simplified process to determine the boundaries of a historic site is: first define each boundary – cultural, political, natural – separately, and then superimpose them upon each other using an overlay process. It is useful to indicate the relative importance of the boundary (e.g. the impact it has had on the landscape) by a variety of graphic techniques. This composite image will indicate a recommended approximate boundary for the historic site.

Boundaries and enclosures set out the perimeters and identify and delineate areas of control and use, either for the overall site or for segments of it. They may take the form of fences, hedges, walls, gates, tree lines or natural barriers. Site recording will often detail materials, construction, vegetation and conditions.



A sieve or overlay mapping method for identifying boundaries for an historic site is an effective means of evaluating and interpreting the development of an area and its evolution.

Boundary demarcations and enclosures are extremely important to the overall understanding of the site. Because they form the walls, dictate spatial organization and reveal the original design intent, their placement and their materials and methods of construction are important to record.

Enclosures served an important function as protection and proof of land grants or purchases. This is reflected in government records of the rulings and regulations passed by early courts. In 1802 the town of York decreed "A legal fence shall be the height of five feet and there shall be no space through the fence of more than four inches."

The earliest fence construction was a palisade. These were probably round posts or stakes with pointed tops, set vertically in the ground tight together. Palisade fences would have required an enormous amount of wood and would have needed continual replacement. Palisade enclosures also known as *pieux en terre* (stakes in earth) or *pieux debout* (stakes upright) were generally found in French settlements.

Champlain, in his description of St. Croix, described buildings which appeared to have been built of horizontal log. What Champlain called *palisado* resembles a post-and-rail fence.

In most instances the availability of material determined what would be used to construct enclosures. For example, split rail was used from the mid-17th to the mid-19th centuries.

Where stone was plentiful and fields were cleared, field stone walls were the rule. Drywall and mortared stone were both used. In places like Kingston, Belleville, Brockville, Guelph and Galt, cut stone was used to make garden walls.

By the middle of the 19th century, owners of substantial residences with formal walls and fences tended to use *cast iron* and *wrought iron*. These materials were often placed on top of a low stone wall and lead poured into the joints to reduce stresses from expansion. For living barriers, see below.

2.4 SITE ARRANGEMENT

Site arrangement is the internal placement of elements such as plant material, fences, paths and buildings within a discrete landscape setting. It provides much of the historic significance, gives information on the impact of various technologies and offers a fuller understanding of landscape styles.

It is the aspect of style and how "style" or "taste" was translated into a given physical form which dictated site arrangement. For example, at Grange Park, Toronto, the landscape arrangement must be understood and interpreted as much more than just a physical plan – it is a social statement.

In the colonies, any individual with time and money who wished to show outsiders that he or she was a person of taste and sensibility undertook "improvements" in keeping with

Department of Indian Affairs and Northern Development
Ministère des Affaires indiennes et du Nord canadien

RESTORATION SERVICES – SERVICES DE RESTAURATION

CLASSIFICATION OF ARCHITECTURAL COMPONENTS
CLASSIFICATION DES ÉLÉMENTS ARCHITECTURAUX

ENCLOSURE FENCING
PALING FENCES
CONSTRUCTION

F / P

File – Dossier

Location – Endroit: ENGINEER'S COTTAGE, LOWER FORT GARRY 1

Date: 1875

Source: INTERPRETIVE PHOTOGRAPHS

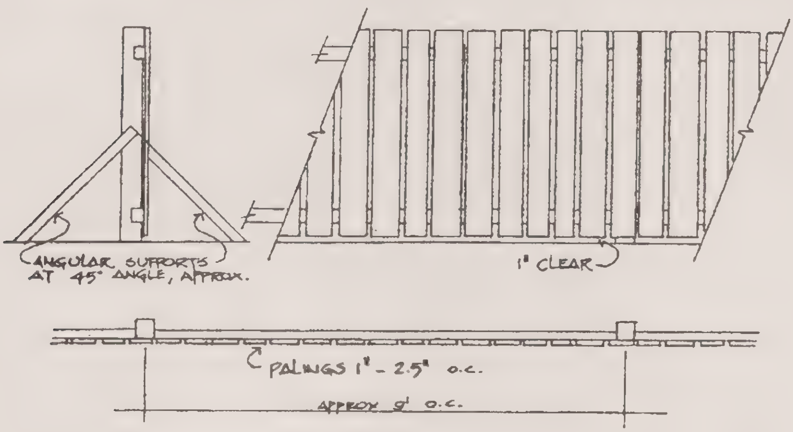
Period: LOWER FORT GARRY

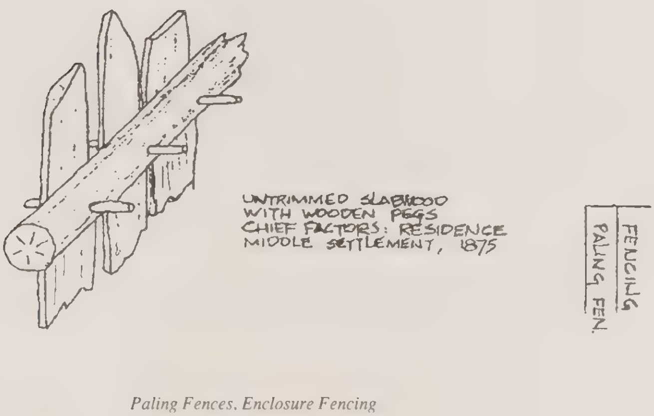
Scale – Echelle: 1/2" = 1'-0"

Drawn by – Tracé par: DB

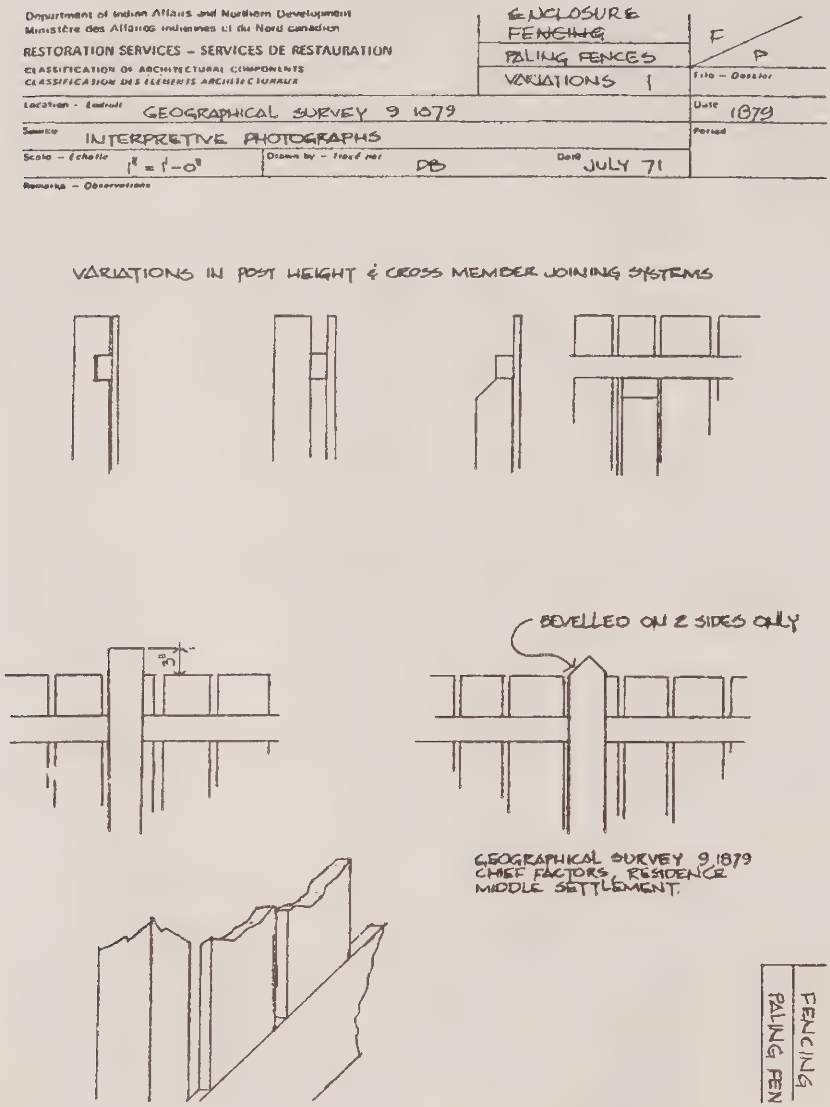
Date: JULY 71

Remarks – Observations

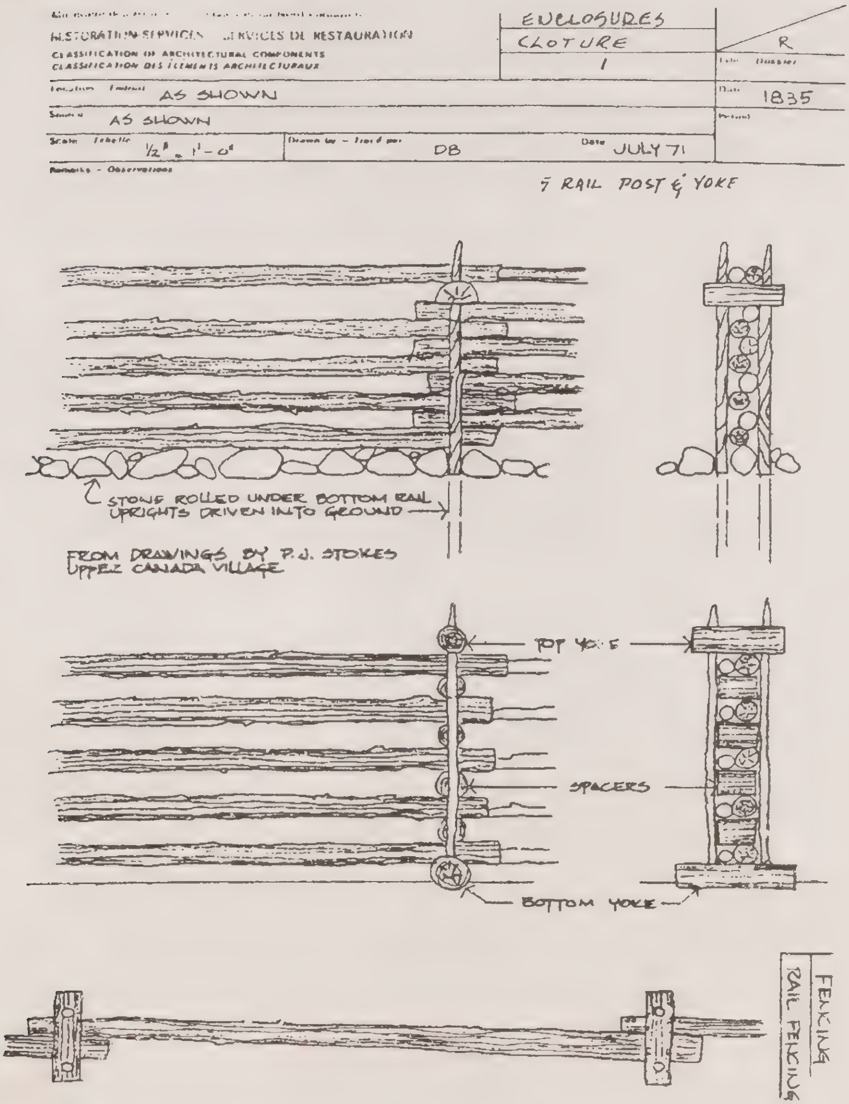




Paling Fences, Enclosure Fencing



Paling Fences, Enclosure Fencing



Enclosure Fencing

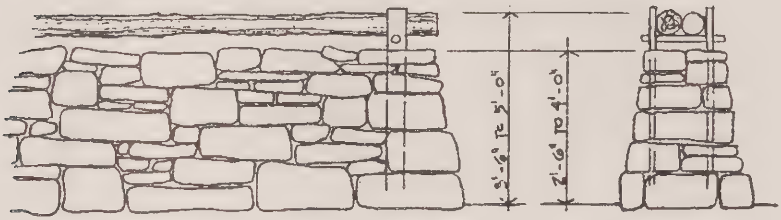
Department of Indian Affairs and Northern Development
Ministère des Affaires indiennes et du Nord canadien

RESTORATION SERVICES – SERVICES DE RESTAURATION

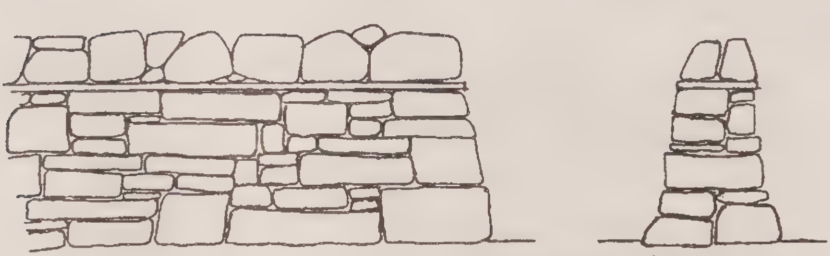
CLASSIFICATION OF ARCHITECTURAL COMPONENTS
CLASSIFICATION DES ELEMENTS ARCHITECTURAUX

	ENCLOSURE FENCING	F
	STONE FENCES	5
	2	
UPPER CANADA VILLAGE		Date 1820
Source DRAWINGS BY Y.J. STOKES		
Scale Échelle $\frac{1}{2}'' = 1'-0''$	Drawn by UB	Date JULY 71

Remarks Observations



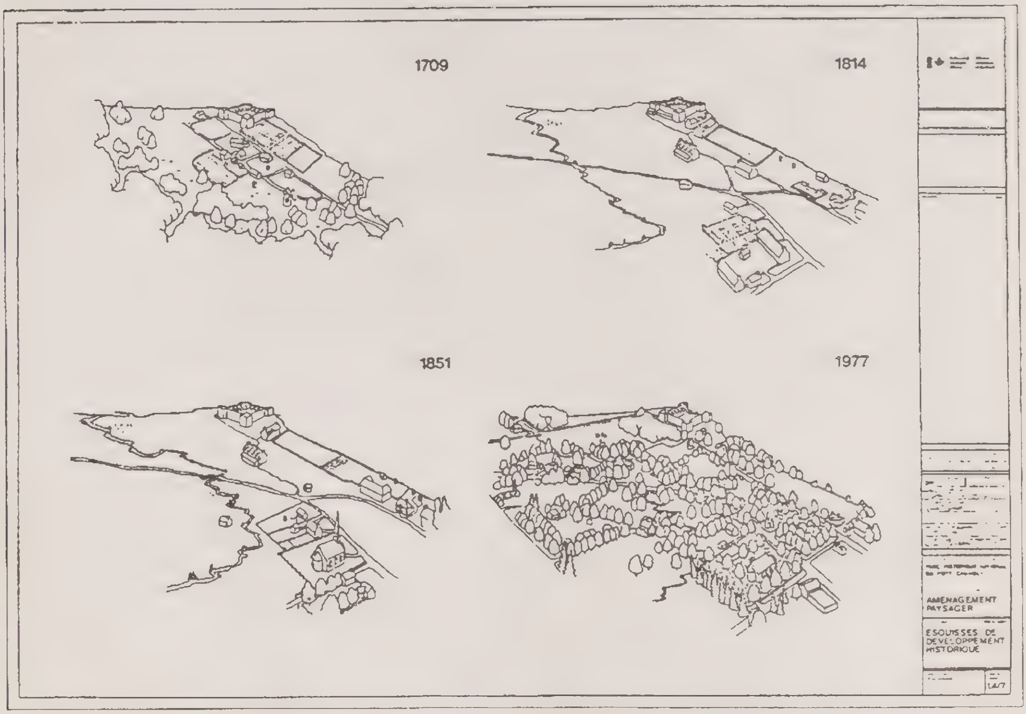
LOG TOP WITH UPRIGHTS & CROSSPIECE
ON COURSED RANDOM RUBBLE
USING ROUGH QUARRY STONE OR
FIELDSTONE & QUARRY STONE MIXED



CAP OF UPRIGHT SLABS OR
MORTARED COPING ON
WOOD SLAB SHIMS OR PLANK

FENCING
STONE FENCING

Stone Fences, Enclosure Fencing



Development of Fort Chambly, PQ

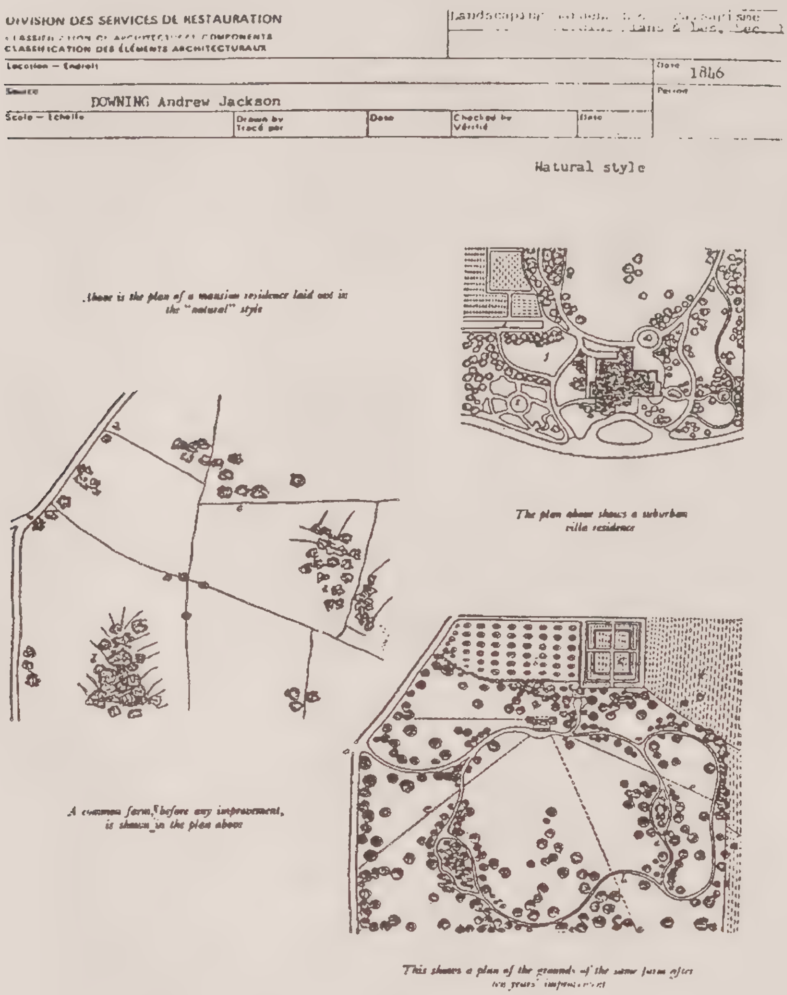
stylized notions of design from the old country. D'Arcy Boulton, Jr. built *The Grange* on a slight eminence. The view from the house down John Street to the lake was a prominent feature of the landscape design. From the entrance gate, features were arranged to encourage the viewer to participate in a picture whose elements led the eye to the entrance porch. The use of the lawn, the terracing, the straight path within the curved drive and the portico at the front entrance was a simple, powerful treatment. It spoke of the broad-scale thinking of the time and of the position the Boulton family had established.

The factor of time, period condition and the levels of maintenance also affect a site's arrangement and evolution. The perspectives taken from plans of Fort Chambly over four periods – 1709, 1814, 1851 and 1977 – document the changes that landscape has gone through as uses and perceptions have changed.

2.5 VIEWS AND OTHER PERCEPTUAL QUALITIES

The assessment of visual and perceptual characteristics is not a clearly defined component. Views which were present in past landscapes should be identified. Often they will explain original site selection, orientation of buildings and arrangements of other site features. These views may have been created by selective cleaning or planting. Views from the front door or from known viewpoints in the landscape are temporal in nature, but their determination is an interesting means of recreating the mood or character of an earlier inhabitant.

Attention should be given to the 18th- and 19th-century perception of "picturesque." This perception dictated art form, literature and the treatment of landscape. The formal Beaux-Arts concept of axial relationships preoccupied late 19th-century formal design. Views to adjacent landforms such as water features or distant hills were often intentionally incorporated into the site design.



Examples of landscape design by Andrew Jackson Downing

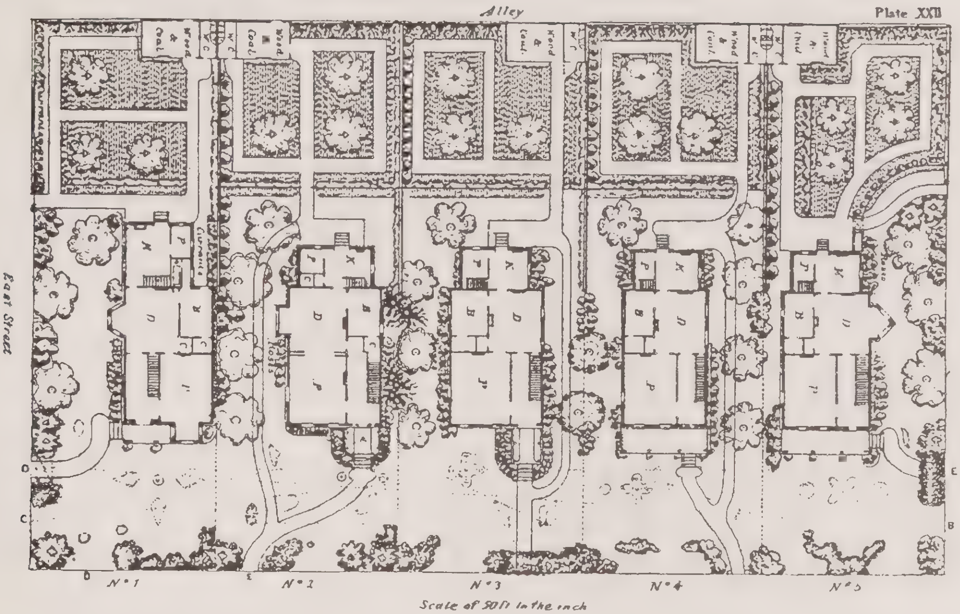
Examples of Landscape Plans Designed by A.J. Downing Showing Before and After Versions of a Farm

The following three plans showing layout organized around views are taken from *Victorian Gardens* by Frank J. Scott, 1870.

2.6 GRADES AND TOPOGRAPHICAL FEATURES

Site contours or grades are essential characteristics of an historic property. The location of a building has often been dictated by terrain and views as were military sites and agricultural layouts.

On Parliament Hill, Ottawa, the original design for the Square was prepared by the New York landscape architect Calvert Vaux in 1873. This layout (see p. 14) including the diagonal paths and circular fountain was constructed, but for a variety of reasons, the paths and the fountain were removed in the mid-1880s. Crop marks indicating the diagonal paths are still clearly visible in the lawn. (Different soil composition, compaction and subsurface drainage result in different rates of plant growth and the formation of crop marks which can be of great aid to the researcher. New York Public Library.)


Alley
Plate XXII
East Street
N° 1
N° 2
N° 3
N° 4
N° 5
Scale of 50 ft to the inch

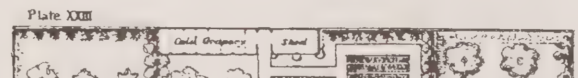
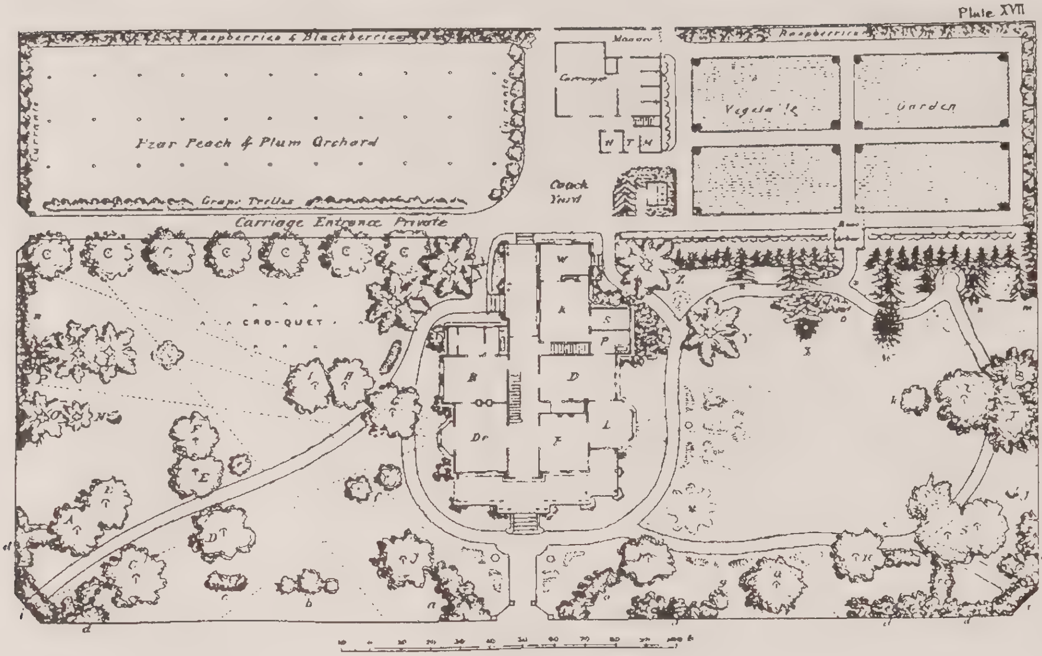
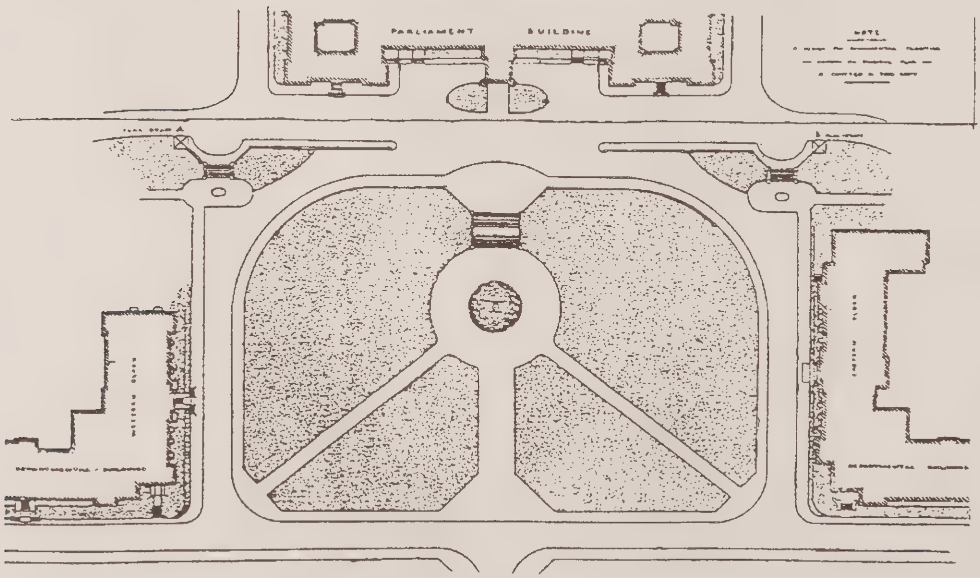


Plate XXIII
Shed

Site Plans



Plan of a Garden, Victorian Gardens, Scott, 1870



Parliament Square by Calvert Vaux, 1873

2.7 WATER FEATURES

Water features on an historic site should be noted. For example, at Bellevue House, Kingston, a pump shared by four properties was an important feature. The canals, irrigation systems, ornamental fountains, wells and pumps were important landscape features and offer potential for interpretation.

As with grades and plant material, existing water features have often been changed. It is essential that all data concerning a water feature be compiled, particularly if a mechanical system was involved either for irrigation or display.

GARDEN SEEDS

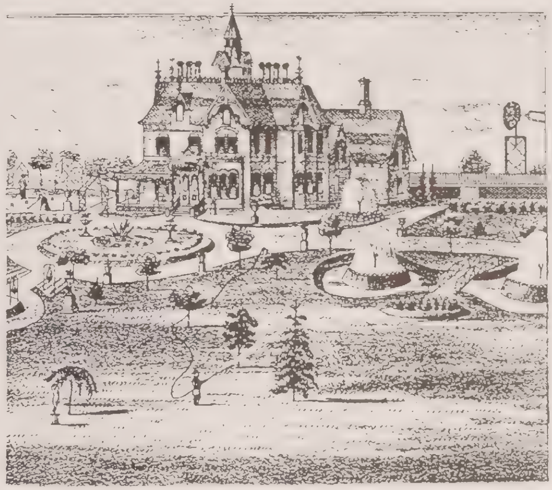
Warranted to be in the Production of Last Year,
and to be sold in Packages of One and a
Half to Three Guineas each, at the Store
of
JAMES COX and Co.
JOHN-STREET, WINDSOR
Assorted as follows:

Bean,	Rape,
Barly Mafigan ditto,	Mixed Lettuce,
Ditto Pease,	Cabbage ditto,
Marrowfat ditto,	Spinage,
Early Horn Carrot,	Green Beet,
Long Orange ditto,	Cellery,
Parsnip,	Mixed Endive,
Onion,	Early Cabbage,
Leek,	Late ditto,
Early Stone Turnip,	Colleflower,
Mixed Radish, Short	White Broccoli,
Top and Salmon,	Purple ditto,
Turnip Radish,	Parsley,
Mustard,	Savoy and
Cress,	Mixed Kidney Beans
Salad Radish,	

LIKEWISE,

Some GRASS SEEDS, of different Kinds,
to be sold as above, for CASH.

James Cox seed advertisement, Port Roseway Gazette and Shelburne Advertiser, *Shelburne, NS, 19 May 1785.*



This illustration of Ellesmere Hall in Oshawa, ON, from the County Atlas gives a good indication of the elaborate system of water features – fountains, ponds and a system to water lawns, all powered by a windmill – available to prosperous home owners in 1877.

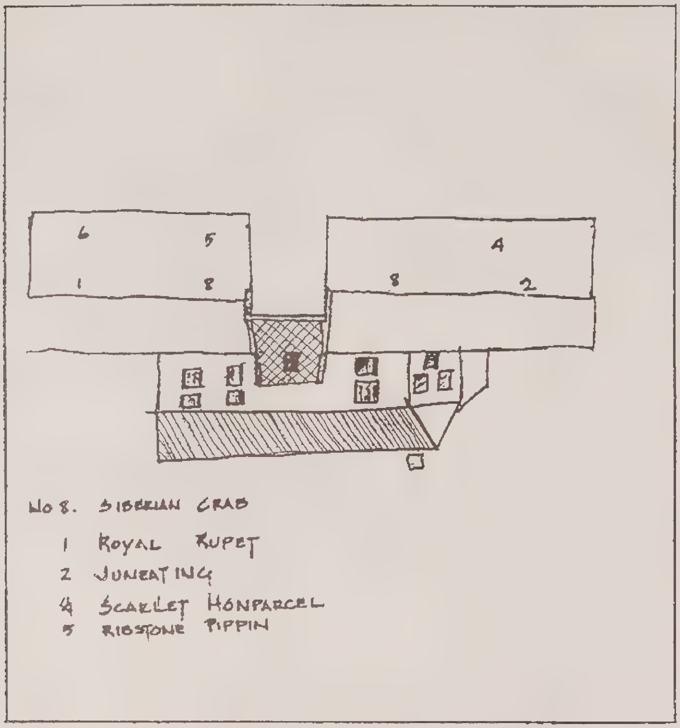
2.8 PLANT MATERIALS

Developing an acceptable approach to the integration of existing plant materials is the most difficult aspect of the design development phase. The varieties of plant material used and their arrangement can provide an excellent record but they rarely represent a single period in time.

The vegetation will have matured to a greater or lesser extent through time and natural actions. As well, new varieties of trees and shrubs will have been added.

It is important that the original intent of the designer is understood. Botanical and horticultural accuracy are as important as topographic or aesthetic veracity.

Original plant lists for the site are rarely found; therefore, one must depend on allied sources. There should be an attempt to use plant material appropriate to the period and those plants known to have been introduced to the area prior to the date at which a restoration has been set. To do this, it is necessary to search out references which describe plants existing in the area even if the researcher is uncertain whether they were grown on the particular site.



Tree Planting for Eildon Grange Garden, Sibbald Point, Lake Simcoe, ON (from the diary of Thomas Sibbald, November 7, 1842)

The first known attempt to bring European plants and animals to Canada was made by Jacques Cartier in 1541. In a Cap Rouge garden, cabbages, turnips, lettuce and other French seeds were planted. All appear to have done well. Champlain conducted numerous tests and experiments in the new settlements at St. Croix (1604) and Port Royale (1605).

It was not until 1617 that any real attempt at farming was made. Louis Hébert, referred to as the first true "colonist" and the "Abraham of the Colony," founded a home and farm in Quebec. Champlain gives an account of this farm.

> I inspected everything; the cultivated land which I found sown and filled with fine grain, the gardens full of all kinds of plants, such as cabbages, radishes, lettuce, purslain, sorrel parsley and other plants, squashes, cucumbers, melons, peas, beans and other vegetables as fine and so well forward as in France, together with the vines brought and planted here...

Religious orders did a great deal to bring plant materials to New France. The Jesuits were particularly interested in advancing the colony. They felt that the chief hope of converting the Indians lay in persuading them to adopt a sedentary life. "We shall work a great deal and advance very little if we do not make these barbarians stationary," was written in *The Jesuit Relations and Allied Documents.*

Chapter 8 of the *Histoire Véritable* discussed horticulture in New France. Not only did author Pierre Boucher list the grains that grew (wheat, rye, barley and oats), the vegetables (peas, lentils, beans, turnips, beets, carrots, parsnips, salsify, cabbage, asparagus, chard, spinach, lettuce and chicory), the herbs (leeks, onion, sorrel, garlic, chives, parsley, borage, hysop, bugloss), melons, cucumbers, watermelons and gourds, but he also writes of flowers in old French:

> Pour des fleurs, on n'en a pas encore beaucoup apporté de France, sinion des Roses, des Oeillets, Tulipes,

> Lysablancs, Passes–roses, Anemones, Pas D'alouette qui sont tout comme en France (Boucher, p. 84).

Besides these importations, Boucher noted wild flowers – yellow Martagons, wild roses, red Cardinal flower, lilies, lily-of-the-valley and violets.

Swedish botanist Peter Kalm's journal for 1749 includes descriptions of Canadian flora and, more importantly, descriptions of 18th-century Canadian plantings:

> August the 7th, en route to Quebec City:
>
> Kitchen herbs succeed very well here. White cabbage is very fine but sometimes suffer greatly from worms. Onions (Allium cepa) are very much in use here together with other species of leeks. They likewise plant several species of pumpkins, melons, lettuce, wild chicory or wild endive. ...Throughout all North America the root cabbage (Brassica gongylodes L.) is unknown to the Swedes, English, Dutch, Irish, Germans and French. Those who have been employed in sowing and planting kitchen herbs in Canada and have had some experience in gardening told me that they were obliged to send for fresh seeds from France every year, because they commonly lose their strength here in the third generation and do not produce such plants as would equal the original ones in quality (Kalm, pp. 438-39).

Kalm further described the garden of the Quebec convent:

> August the 8th the Quebec Convent.
>
> ... on one side of the convent is a large garden in which the nuns are at liberty to walk about. It belongs to the convent and is surrounded with a high wall. There is a quantity of all sorts of vegetables in it and a number of apple, cherry and white walnut trees and red currant bushes...(Kalm, p. 445).

In Upper Canada, a variety of plant materials was available early in the 19th century. The following advertisement for a seed catalogue appeared in the *Upper Canada Gazette* for 1 April 1819:

> *York Gardens* – Messrs. Tudger and Darker, respectfully inform the gentlemen of York and its vicinity that they have the following Garden and Flower seeds for sale of last year's growth and warranted.

GARDEN SEEDS	FLOWER SEEDS
Early York Cabbage	Mignonette
Drum head or winter	Sweet Pea
Savory	Rose Lupin
Curled Kale	Larkspur
Red	Nasturtium
Early Cape Broccoli	Coxcomb
Blood Beet	Balsam
Carrot	China Hollyhock
Parnsip	White Brompton
	Stock
Onion	Scarlet Ten Week
Long prickly Cucumber	Globe Amuranthus
Melon	Carnation Pink
Water	Indian do
Large Pumpkin	Sweet William
Squash	Convolvalus Majo
Grand Admiral Lettuce	Two year old
	Asparagus plants
Ice	
Malts	
Round Spinach	

Several lists of plants known to have been grown in a particular area during a particular time are available and these should be used when documenting a site. Several are listed in the bibliography.

2.9 STRUCTURES AND ACCESSORIES

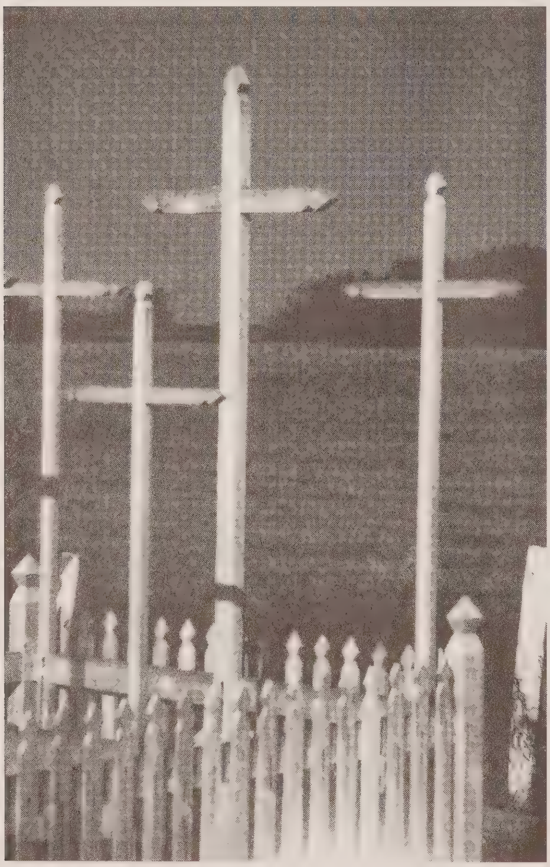
Architectural and structural elements, as well as additional accessories, are important adjuncts to any historic landscape or garden. These elements give the site added interest.

Extant structures and accessories should be carefully recorded and conserved. These may include shelters, treillage, gazebos, seats, benches, signs, garden ornaments, flagpoles, exterior lighting and streetscape elements. Appropriate treatment of the structures and accessories will normally require expertise in historic materials conservation such as masonry, wood, metals, paints and plaster.

At the Motherwell Homestead Historic Site, research indicated the correct functioning of the gardens. For example, the reconstructed hot-bed was placed in the same location as the original structure, next to the implement shed. There it benefitted from a southern exposure and was protected from harsh north-westerlies.

To restore this landscape feature, an abundance of structural and operational information on hot-beds were available from archaeologists and period farm literature. Like its predecessor, the new hot-bed is built over a manure-filled hole. As the manure slowly decomposes, it generates warmth which promotes the growth of less hardy seedlings during early spring.

Similarly fences and gates were an important feature of the Homestead. They helped to reinforce the effect of the tree belts in dividing the property into its network of quadrants.



Cemetery – Batoche National Historic Park, SK

Through the use of three different fenceline designs, the various areas were either highlighted, barricaded off or completely screened. All contributed to the well-ordered nature of the farm core. The fencing included the six-strand page wire (farm) field fence, the unpainted high board barnyard fence and the ornamental woven wire front fence.

The fenceline reconstruction proved to be one of the most challenging aspects of the project because of the difficulty in obtaining the metal portions of the fence fabric, gates and hardware. This period metal work is, to the best of the researchers' knowledge, no longer manufacturered.

3.0 PERIOD LANDSCAPE TECHNIQUE

3.1 GARDENING TECHNIQUE AND PLANT CARE

In addition to understanding the plant materials and techniques used in past eras, it is important to have a knowledge of the planting and cultivation theory of the day. The following example demonstrates the theory:

During the early 19th century, J. C. Loudon and his protegé in North America, A.J. Downing, discussed the clumping of trees and recommended suitable combinations as an integral part of the laying out of an "English landscape." Downing in his *Theory and Practise of Landscape Gardening Adapted to North America* devotes considerable text to suitable trees for both the "beautiful" and the "picturesque" and their grouping to produce the desired effect. He writes, for example, "Larch and fir trees and some oaks may be taken as examples [of the picturesque]." This kind of distinction in the perception of the original landscape architect could easily go unnoticed on a site unless a researcher was familiar with Picturesque theories of landscape design and had the ability to recognize the meaning of the different types of plant material.

There were some traditional customs regarding where particular plants should be placed. Lilac became almost synonymous with the outhouse, lily-of-the-valley and periwinkle with the north wall of the house. If, therefore, in carrying out fieldwork, a mass of periwinkle is found, there is a good chance of unearthing the foundations of a structure at that place. It was customary among some cultural groups to plant two evergreens or two fruit trees on the front lawn when a couple were married. Planting a tree with the birth of each child was also very common in certain regions. These were lined up across the front property line.

Certain plants were used because of their ability to withstand harsh treatment. Daylily *(Hemerocallis fulva)* was often planted near the back or kitchen door because of its ability to withstand the lye soap in the dirty wash water thrown on it. Another name for it was gully-lily because it was frequently used to check erosion on ditches and steep slopes. It is often seen along the laneway or the front ditch of older properties.

3.2 TYPES OF FACILITIES

A number of different kinds of facilities are associated with historic sites. These include service areas, natural areas, period grounds, cultivated areas, canals and water-oriented areas, military earthworks, cemeteries, streetscapes and archaeological sites.

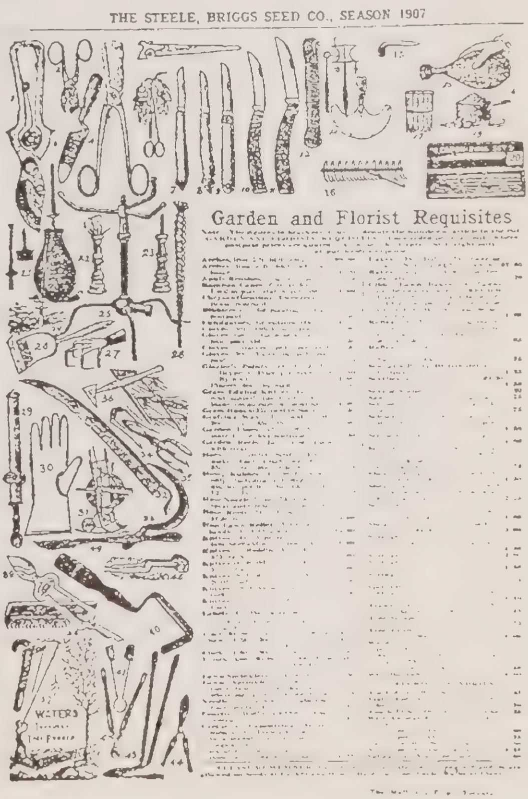
Frontispiece, Everyman his Own Gardener

3.3 TOOLS AND TECHNIQUES

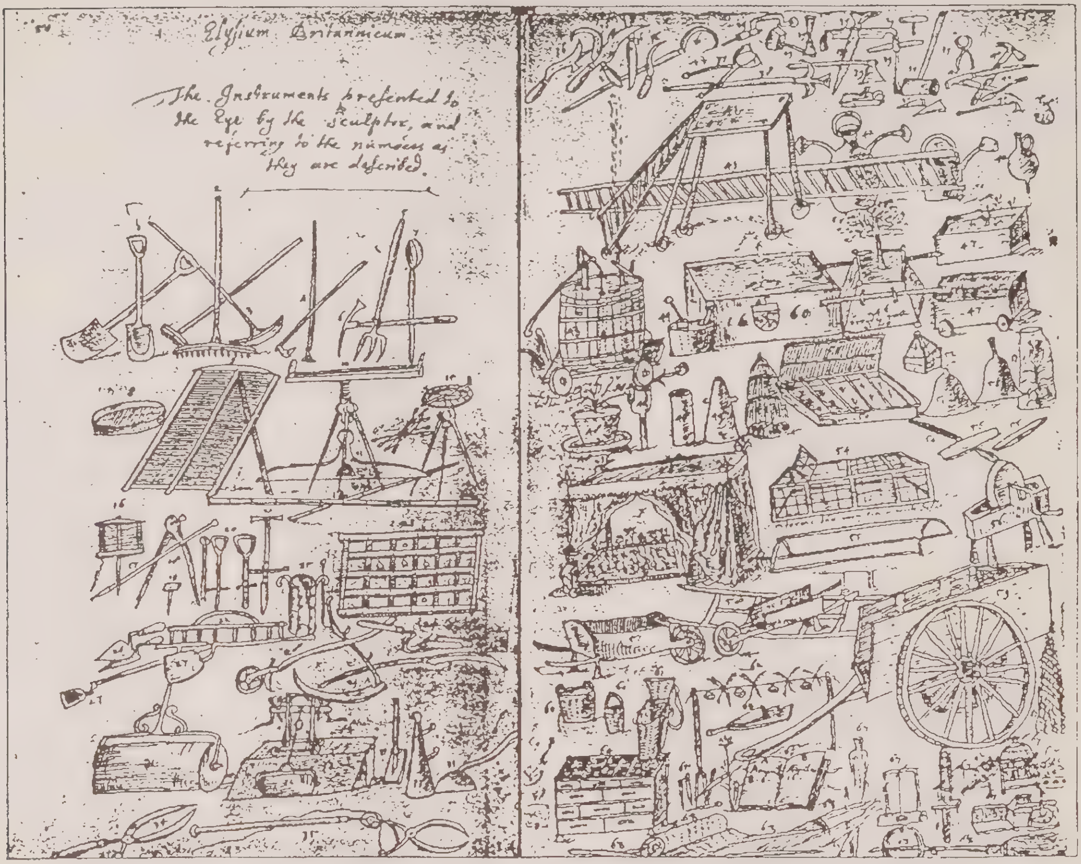
The design of garden implements has changed so little that a 16th- or 17th-century gardener visiting a 20th-century tool shed would be surprised only by the innovation of stainless steel and our use of forks for digging. Tools for grafting and pruning, an important skill in the 16th century, are strikingly similar to those today.

Publications such as *Agricultural & Horticultural Implements*, published by John Mather & Co.'s United States Agricultural Warehouse, New York, abounded throughout the 19th century. In western Canada a considerable number of these catalogues were compiled as part of the Motherwell Homestead restoration.

Tools and equipment used in the West were available through a complex distribution system. Ashdown's in Winnipeg was the largest supplier around the turn of the century and had large depots in several cities. Companies such as the Steele, Briggs Seed Company published catalogues offering a range of tools for the gardener.



Gardening tools used during the period of restoration
(Steele, Briggs Seed Company's 1907 plant catalogue, Winnipeg, MB)



The implements shown are John Evelyn's gardening tools as used and drawn by him ca. 1660, from his unfinished and unpublished Elysium Britannicum

4.0 BIBLIOGRAPHY

Anthony, John. 1972. *Discovering Period Gardens.* Shire Publications, London.
Surveys development of gardens in Great Britain through history.

Binney, Marcus and Ann Hill. 1979. *Elysian Gardens: A Strategy for Survival.* Save Britain's Heritage, London. Numerous illustrations show how styles of gardens have changed in the course of the last century. It focuses on the need for protection and means to facilitate the preservation of gardens.

Boucher, Pierre. 1664. *Histoire Véritable et Naturelle des moeurs et productions du pays de la Nouvelle-France vulgairement dite Canada.* Paris. Reprinted 1964, Societé Historique de Boucherville, PQ.

Brunet, Ovide. 1939. *Journal de voyage en Europe de l'abbé Ovide Brunet en 1861.* Le Canada français, Arthur Maheux.

Champlain Society. 1922. *Works of Samuel de Champlain.* Vol. III. Translated and edited by J. Home Cameron. Toronto.

Downing, Andrew Jackson. n.d. *Cottage Residences, or a Series of Designs for Rural Cottages and Cottage Villas and Their Gardens and Grounds.* Reprinted 1967, American Life Foundation, Watkins Glen, NY.

__________. ed. 1853. *Horticulturist Journal of Rural Art and Rural Taste.*
Publication included articles on Canadian gardens and horticultural matters such as in the April issue a practical observer described "Gardens and Gardening in Montreal."

__________. 1859. *A Treatise on the Theory and Practise of Landscape Gardening Adapted to North America 1841.* A.O. Moore & Co., New York. Funk and Wagnalls, 1967.
Illustrates early American gardening practices.

Favretti, Rudy J., and Gordon P. DeWolf. 1972. *Colonial Gardens.* Barre Publishers.
Contains useful plant lists and practical information for the restoration of early American gardens.

Favretti, Rudy and Joy Favretti. 1977. *For Every House a Garden.* Pequiot Press, Chester, CT.

Gauthier, Jean-François. 1744. "Observations botanico-météorologiques faites à Québec par M. Gauthier pendant l'année 1743," *Histoire de l'Académie royale des sciences.* Section des Mémoires, pp. 135-55.
This is one of five publications Gauthier prepared between 1748 and 1754 of excerpts from M. Gauthier's observations.

Gentilcore, R. Louis and C. Grant Head. 1984. *Ontario's History in Maps.* University of Toronto Press, Toronto.

Harvey, Mary MacKay. 1975. "Gardens of Shelburne, Nova Scotia 1785-1820," *Bulletin of the Association for Preservation Technology,* Vol. 7, No. 2, pp. 32-72. Ottawa.

Kalm, Peter. 1966. *Travels in North America.* Vol. 2. Revised and edited by Adolph B. Benson. Dover Publications, New York.

Leighton, Ann. 1970. *Early American Gardens for Meat and Medicine.* Houghton Mifflin Co., Boston.

Mather, John, & Co. 1850. *Agricultural & Horticultural Implements at John Mather & Co.'s United States Agricultural Warehouse, 197 Water-street, near Fulton St, New York.* Geo W. Wood, Printer, 15 Spruce-Street, New York.

Melnick, Robert J., Daniel Sponn and Emma Jane Saxe. 1984. *Cultural Landscapes: Rural Historic Districts in the National Park System.* National Park Service. U.S. Department of the Interior, Washington, DC, p. 17.

Michaud, Claude. 1983. "Analysis of Architectural Landscape," *Bulletin of the Association for Preservation Technology,* Vol. 15, No. 4.
This is part of a macro-inventory guide carried out by Quebec. It is the study of places and the hypothesis that there are two main aspects of how popular architecture and land use contribute to creating specific architecture.

Minhinnick, Jeanne. 1970. *At Home in Upper Canada.* Clark Irwin, Toronto, pp. 216-21.
The plants listed were known to be available in the northern United States and presumably in Upper Canada before 1860. Plants not procurable in Canada before 1840 are described. All names mentioned were in contemporary sources; books on life in Upper Canada, advertisements, nurseryman's catalogues and books on gardening in the northern United States which were sold in Canada. Native plants are included if they were cultivated in gardens or gathered for kitchen use.

Olmsted, Frederick Law. 1859. *Walks and Talks of an American Farmer in England.* Reprint. Ann Arbor, MI.

Schmidt, Carl F. 1963. *Fences, Gates and Garden Houses.* Rochester, NY.
Measured drawings and photographs of early 19th-century examples of these important garden elements.

Scott, Frank J. 1870. *The Art of Beautifying Suburban Home Grounds of Small Extent.* D. Appleton & Co., New York. Reprint title: *Victorian Gardens.* 1977. American Life Foundation, Watkins Glen.
Refines theories of Downing and includes numerous examples of their practical application to domestic landscapes.

Sharpe, Grant W. 1976. *Interpreting the Environment.* John Wiley and Sons Ltd., New York.

Sykes, Meredith, and John J. Stewart. 1972. "Historic Landscape Restoration in the United States and Canada: An Annotated Source Outline," *Bulletin of the Association for Preservation Technology,* Vol. 4, Nos 3-4, pp. 114-58.
A suggested outline for classifying material on historic landscape preservation under five headings.

Toronto, Garden Club of. 1970. *Plants of Pioneer and Early Days in Ontario.* Toronto.
This booklet of pre-1867 plant material in Ontario was prepared by the Garden Club of Toronto as a project to plan and plant authentic and appropriate gardens at the Black Creek Pioneer Village. Information is based on amateur investigation of old books, papers, catalogues and diaries for information on the subject of early material. Dates of reference are given for each variety cited. The material included is divided into sections for annuals, biennials, perennials, bedding and house plants, herbs, drugs, roses, soft garden fruits, tree fruits, garden vegetables, field crops, grasses, bulbs and corms, vines and creepers, shrubs, ornamental trees, deciduous and coniferous trees, native species and ferns.

A LIST OF CANADIAN NURSERIES

In *Rural Affairs*. Albany – 1858-60, Vol. 2. gives some indication of the availability of plant material grown in Canada, particularly in Canada West – C.W.

- Charles Arnold, Paris, C.W. 1852 – 5 acres all fruit trees
- Thomas Burgess, London, C.W. 1854 – 10 acres
- Robert Caines, Galt, C.W. 1851 – 10 acres all fruit trees
- J. Callwell & Brothers, Waterloo, C.W. 1848 – 40 acres chiefly fruit trees – 1 green house
- James Dougall, Windsor, oppos. Detroit
- Dunning, Campbell & Co., Wellington Sqr., C.W. 20 acres
- Fairchild & Kelsey, Mohawk, P.O. Grant Co., C.W. 1849 – 14 acres
- D. Fisher, Bowmanville, C.W. 1850 – 20 acres fruit and ornamental
- James Flemming, Yonge St., Toronto – Nurseryman and seedsman. 1842 – extensive greenhouses
- J.W. Gilmour, Peterboro, C.W. 1851 – 20 acres fruit and ornamental and 1 good greenhouse
- James Greig, Pickering, C.W. 1848 – 15 acres
- E. Hubbard, Guelph, C.W. 1848 – 10 acres all fruit trees
- E. Kelly & Co., Hamilton 1840 – 60 acres chiefly fruit trees – a vigorous establishment

- George Leslie Toronto, C.W. 1844 – 75 acres 3/4 fruit trees of the most extensive nurseries – if not the most so in Canada
- B. Losie, Cobourg, C.W. 1854 – 10 acres
- I.P. Lovekin, Newcastle, C.W. 1848 – 30 acres mostly apples and cherries and a share of ornamentals, chiefly evergreens
- D. Nichol & Co., Lyre near Brockville, C.W. 1854 – 8 acres
- J.P. Thomas, Belleville, C.W. 1852 – 8 acres, fruit and ornamental
- John S. Walker, Erie, C.W. 28 acres

Illustrations are the property of the Heritage Conservation Program, unless otherwise noted.

Canadä